MEMBER A. B. C.— A. B. P.

JUNE, 1940

THE Petroleum Engineer

VOL. XI—NO.

The PETROLEUM ENGINEER PUBLISHING CO. . . . Telephone 2-4571 . . . Seventh Floor Allen Building . . . DALLAS, TEXAS

A Magazine of Methods for Operating Men

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The Course of Oil

By K. C. SCLATER

Commission's Judgment Upheld

A revision of oil allowables in Texas is likely. The Railroad Commission has been sustained by the Supreme Court of the United States in its proration regulations of August 29, 1938, for the East Texas field. These proration regulations were changed on September 11, 1939, because of an adverse decision of the federal district court. Now that the lower court's ruling has been reversed by the Supreme Court of the United States it is believed that the Commission will revert to the old regulations, and this implies that neither acreage nor reservoir conditions will be taken into account.

The Supreme Court's ruling places on the Texas Railroad Commission the full responsibility of issuing regulations that are equitable. It said, "It is not for the Federal Court to supplant the Commission's judgment even in the face of convincing proof that a different result would have been better."

One underlying cause of trouble in setting allowables in the East Texas field is the marginal well law. The figure of twenty barrels per day for marginal wells is believed by many to be more or less arbitrary. It assumes that this is the minimum allowable that will give the producer an adequate return on his well investment. This generous marginal allowance has led to many requests for special drilling permits and exemption from Rule 37.

A sound basis of allocation production in any field should take into account reservoir conditions. When wells are drilled closer than justified by underground conditions, it leads to economic waste, over-production, and needless proration difficulties.

●

Regulation Problem Acute

What should be the proper well-spacing? This is a question that arises in every newly discovered field. It is one of the most important problems confronted in oilfield development. Its solution involves a consideration of underground conditions. These are not always available until the field is partly developed.

With proration in effect, the trend is toward wider spacing. Notwithstanding this trend, it is found that in Texas the number of wells is increasing at such a rate that the problem of regulation and proration is becoming acute. The charge is made by a member of the Commission that much of the drilling is in proven fields and on inside locations rather than offsets.

Whether this increase in drilling is the result of anticipation of an increase in demand for oil is not known. The fact remains, however, that without an increase in demand every new producing well means a decrease in per-well allowable. The setting of a top allowable for each field is being talked of as a possible means of discouraging so-called unnecessary drilling. The problem is one that demands the serious thought of every operator in Texas.

Benefits of Reservoir Control

There are today more thon 25,900 producing wells in the East Texas field. Of these, 948 flowing wells and 3,333 pumping wells are producing water with the oil. Of the 6,242 pumping wells in the field, only 2,905 are not producing any water. According to the latest report, the volume of water being produced in the field is about 180,000 barrels.

The number of naturally-flowing wells is decreasing and the number of air-lift, gas-lift, and pumping wells is gradually increasing. The decline in bottom-hole pressure per million barrels of oil is diminishing at an average rate, and the wells as a whole are gradually reaching the pumping stage. Regardless of the field's signs of senility, the transition is gradual and free from the uncertainty that characterized fields before the days of reservoir control. Despite the vicissitudes of regulation in this field in its early days of development, it has a remarkable production record—the result of improved methods of reservoir control. Advantage has been and is being taken of the natural gas energy and a natural water drive. What has been achieved in this field amply demonstrates the advantages of proper reservoir control in contradistinction to the old uncontrolled competitive methods of production.

●

Carbon Black Production

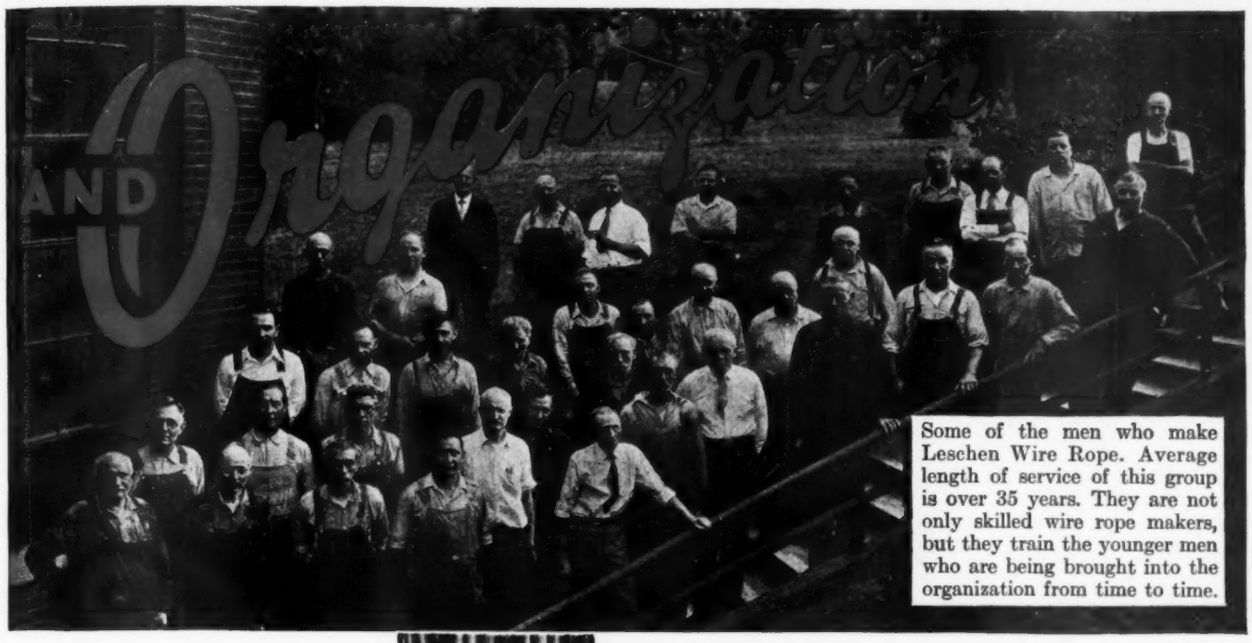
Carbon black production from natural gas during 1939 increased by ten percent over that of 1938. The total production in the United States was in excess of 525,166,000 pounds. Of this amount Texas produced 453,174,000 pounds, Louisiana 51,734,000 pounds, and Kansas and Oklahoma more than 20,000,000 pounds. Wyoming, one of the states that has been producing carbon black for years, is no longer a producer of this by-product. It dropped out of the picture entirely in 1939.

For 1938, the average yield was 1.47 pounds per thousand cubic feet, but during 1939 the average yield was 1.51 per thousand cubic feet of gas, an increase of .04 pound per thousand cubic feet of gas. The average value of the gas used was 94 cents per thousand cubic feet.

Of the more than 356,000,000 pounds of carbon black sold in the United States, 89 percent was for use in the manufacture of rubber, six percent in the manufacture of inks, two percent in the manufacture of paints, and the remaining three percent for use in other miscellaneous industries.

Faced with a gradually increasing cost of its raw material—natural gas—this offshoot of the petroleum and natural gas industry is confronted with the problem of improving the average yield and quality of carbon black by the adoption of more efficient processes. The present average yield does leave much room for improvement.

MATERIALS • METHODS • FACILITIES • EXPERIENCE



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« « HIGHLIGHTS IN OILDOM » »

East Texas Field Rules Amended

As a possible means of lowering water production, East Texas rules have been amended by the Texas Railroad Commission to permit lifting the tubing. The amended rules state:

"Rule 1 (b) All artificial lift wells (pumping, plunger, or gas lift) shall be equipped with and produced through tubing. The bottom of tubing or top of perforations shall not be higher than the top of the producing formation except where such wells are producing both oil and water, whereupon after written application permission may be granted by the deputy supervisor to raise the bottom of the tubing or top of perforations in the well, keeping at all times openings in tubing completely submerged in the fluid."

●

Exploitation of Baku Oil Fields Has Declined

The exploitation of the Baku fields, Russia, has failed to keep pace with the general development of Soviet national economy, according to a report to the U. S. Bureau of Mines from American Consul Charles E. Dickerson, Jr., Moscow. This comment achieves enhanced significance when it is recalled that the Baku fields yielded upward of 78 percent of the total output of crude oil in the Soviet Union in 1938. No figures for 1939 have as yet been issued.

Most of the producing trusts of the district, it is stated, did not fulfill their production program for the year and some of them actually fell below the figure they had reached in 1938. The principal reason for the poor results attained is ascribed to the fact that the decline in the production of old wells is not offset by the drilling of new wells. In 1936 the number of new wells put into operation was 1320; in 1937, it was 1152; in 1938, 910, and in 1939, only 793. Drilling is conducted in an unsatisfactory manner, according to the report, with the number of "churn" drills in use decreasing each year. Other reasons for the low output are given as poor organization of capital repairs on active wells and lack of sufficient attention to prospecting and developing new oil-bearing areas in the district.

●

Ohio Passes Act Allowing Water-Flooding

An act has been passed by the state legislative body of Ohio and signed by Governor John W. Bricker to permit the introduction of water or other liquids under controlled pressure into wells for the purpose of recovering crude oil.

The new law provides that: "The owner or operator of any well or wells within Ohio which produce oil or gas shall be permitted, upon the written approval of the chief, Division of Mines, to allow such well or wells to remain open for the purpose of introducing water or other liquid pressure under control, upon and into any oil-bearing sand for the purpose of recovering the oil contained therein, and shall be permitted to drill additional wells for like purposes, provided that the introduction of such pressure or other liquid into said oil-bearing sand shall be controlled from the ground surface only and shall be through casing or tubing which shall be anchored and packed so that no other oil- or gas-bearing sand and fresh-water strata, above or below, shall be affected by the introduction of such controlled pressure."

The act further stipulates that the chief of the Division of Mines shall not in any case grant such approval if it can be shown that damage to gas wells or the potable water supply will result by the introduction of water or other liquid for the purpose of oil recovery.

●

Submerged Land Title Question Left to Courts

The senate public lands committee has proposed that congress allow the courts to settle the conflict of opinion over whether the federal government or the coastal states hold title to oil-producing submerged lands under this country's territorial waters. The committee reported to the senate that the ownership dispute involved a legal question, settlement of which is of great importance because of the great value of the property involved. The committee recommended enactment of legislation requesting the attorney general to institute proceedings to protect federal interests in the land.

Chairman Adams of Colorado said the attorney general's office had studied the question at length but felt that because of the character of the controversy and the parties to it a resolution from congress requesting them to proceed in the matter was desirable, if not essential.

As it emerged from the committee the redrawn resolution would apply to all submerged lands under the territorial waters of the United States, among them those of Texas and California, the principal states claiming ownership of sub-sea oil deposits. As originally drafted it would have asserted title only to those lands along the California coast.

●

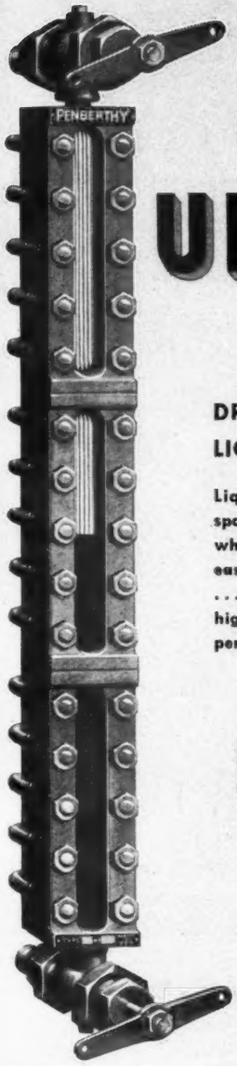
High Court Upholds Commission In Probation Case

The United States Supreme Court has upheld the Texas Railroad Commission in the case brought by Rowan and Nichols Oil Company attacking a proration order relating to the East Texas field.

The proration order attacked was one issued in 1938 under which each well in the East Texas field was allowed to produce 2.32 percent of its hourly potential. In addition, the Commission's order permitted marginal wells to produce to as much as 20 bbl. of oil per day without respect to their hourly potential. Asserting that exemption of marginal wells from the operation of the proration order disregarded the rights of the complaining oil company to recover the oil in place under its leases, Rowan and Nichols was granted an injunction by the district court, enjoining the Commission from carrying out its proration plan. With modification held to be irrelevant, the Circuit Court of Appeals affirmed the district court.

The Supreme Court's decision was by a vote of 6 to 3. Justice Felix Frankfurter delivered the opinion of the court and Justice Owen J. Roberts delivered the dissenting opinion.

This is the first of three similar cases, all based on a challenge of the validity of oil proration orders issued by the Railroad Commission. The Humble Oil and Refining Company and Rowan and Nichols Oil Company are the complainants in the other two cases. When it gave its current decision the United States Supreme Court admitted probable jurisdiction in the Humble case, but declined motion to stay an injunction granted by the lower court and also denied motion to advance. The case will come before the court after its vacation.



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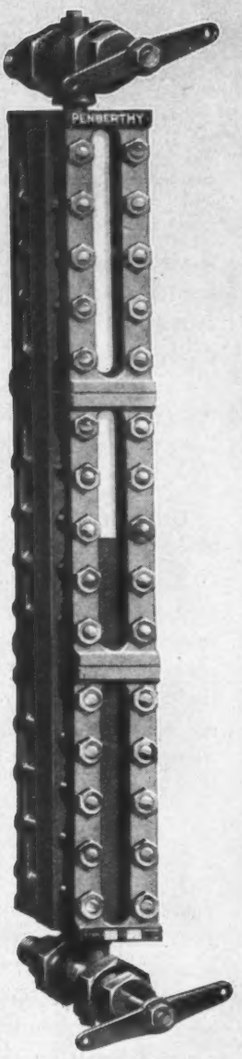

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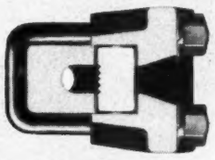

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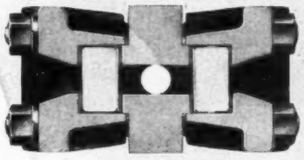

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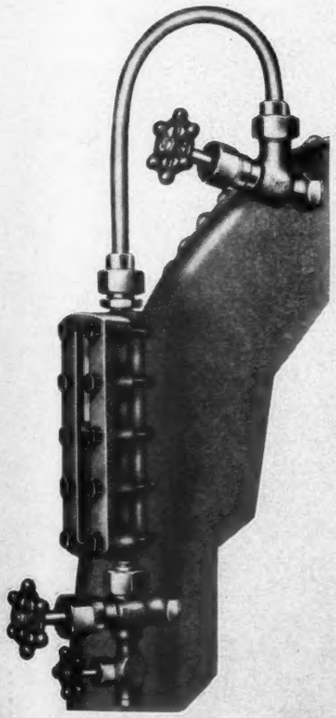

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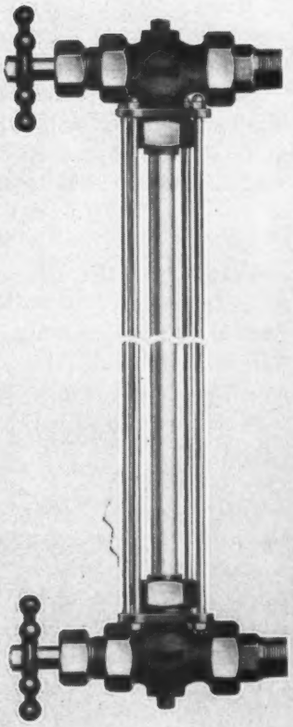

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PENBERTHY PRODUCTS

Major Pipe Line Activities

PANHANDLE Eastern Pipe Line Company has authorized the construction of an additional 105 miles of loops on the main line of the company. In addition, a new 4000-hp. compressor station will be constructed and additions to an existing station will probably be made. This work is in addition to the construction program now in progress, on which work will not be completed until the latter part of July.

●

The capacity of Memphis Natural Gas Company's main 18-in. trunk line from Monroe, Louisiana, is being increased by a looping program, in which a total of 92 miles of 18-in. pipe will be installed over various strategic sections of the system. The contract for the construction work has been awarded to N. A. Saigh Construction Company, San Antonio, Texas. Pipe is now enroute to the initial section, being supervised from a field office established at Greensville, Mississippi. Offices will be moved later to Clarksdale, Mississippi, then to Memphis, Tennessee, as the work progresses.

●

An important addition to the pipe-line facilities in West Texas is the 110 miles of 8-in. being built by Texas-New Mexico Pipe Line Company, one of the principal purchasers of crude oil in the area. The line will originate in the north fields of the Permian Basin and terminate at Midland, Texas, where it will tie-in with the Gulf Pipe Line system, through which oil will be moved to the Crane County station of the Texas-New Mexico Pipe Line Company.

●

Illinois Pipe Line Company has made preliminary plans to construct 50 miles of 8-in. crude oil pipe line between Centerville and Bridgeport, both in Illinois. Plans include erection of three 55,000-bbl. storage tanks near Centerville. The line, to have a daily capacity of 35,000 bbl., will serve as an outlet for production from several southern Illinois fields, including the Lancaster and Albion areas.

●

Cities Service Gas Company is proceeding with plans to build 60 mi. of 12-in. pipe line to transport natural gas from the Cunningham field, Kingman and Pratt counties, Kansas, to Wichita. This outlet will permit more of the Cunningham reserve to be produced and will provide Wichita with gas produced within the state.

●

The contract has been awarded by Northern Natural Gas Company, Omaha, Nebraska, to C. S. Foreman Company, Kansas City, Missouri, for the construction of 66 miles of 24-in. gas transmission line in 4 loops between Mullinville, Kansas, and Beatrice, Nebraska. These extensions are loops on Northern Natural Gas Company's main line extending to Omaha and Minneapolis from the Panhandle and Hugoton, Kansas fields. The lines are to be solid welded and the contractor will do his own electric welding.

C. S. Foreman Company was also awarded contracts for the construction of additions of 1300 hp. to each of the gas compressor stations at Bushton, Kansas, and Beatrice, Nebraska.

●

A 6-in. pipe line was recently laid from Stanolind Oil & Gas Company's No. 1 John A. Hulen well in the Asa Brigham Survey, Galveston County, Texas, to the Pan American Refinery at Texas City, a distance of 15 miles. Work was completed in 6 days. Williams Brothers Corporation, Tulsa, Oklahoma, was the contractor.

Capacity of the line is 500 bbl. per hr. and it will be taxed to capacity until the well is brought more fully under control. The well is now flowing on two ¾-in. chokes with pressures of 1000 lb. on the tubing and 1400 lb. on the casing, and is producing about 450 bbl. per hr.

●

Contracts will be awarded soon by Manufacturers Light and Heat Company, an eastern company, for construction of 117 miles of 8-in. gas pipe line from Olean, New York, to Brookville, Pennsylvania, and for 12 miles of 8-in. gas pipe line between Monaca and Ellwood City, Pennsylvania, north of Pittsburgh.

●

An application has been filed with the Federal Power Commission by Western Natural Gas Company for authorization to construct a 770-mile pipe line to transport natural gas from the Hugoton field in Kansas to Milwaukee, Wisconsin. The company plans to enter into contracts with Milwaukee, Madison, Beloit, Janesville, Racine, Kenosha, and Port Washington, all in Wisconsin, and Dubuque, Iowa—all communities not now being served with natural gas.

●

Natural gas from the Bowdoin gas field in Valley and Phillips counties, Montana, will be transported through 110 miles of 8-in. pipe line to near Glendive, Montana, to be constructed by Montana-Dakota Utilities Company, Minneapolis, Minnesota.

The new line will connect at Glendive with the main line of the company, through which gas is supplied to various municipalities in Minnesota and North Dakota.

●

Argentina, through its petroleum agency, Y.P.F. (Yacimientos Petroliferos Fiscales) is formulating plans for 1941 that include the construction of 550 miles of 12-in. crude oil pipe line from the Lulunta and Tupungato fields in the western part of the country to a terminal on the Rio Parana, thus gaining an outlet to the Atlantic.

NEW RECORDS are in the Headlines

"They call me, 'Decathalon Fleetweld' because I excel in so many events. I *run* fast and smooth. I *hurdle* production obstacles. I *heave* more metal into the joint—less into spatter. I *jump* into new fields to conquer. I *throw* light on tough welding problems. I *vault* to new highs in weld quality and economy.

"Where do I get such versatility? From the inherent ability given me by my maker to win over others of my type. And I'm aided a lot by a versatile welding control—that of the New *'Shield-Arc'* and *'Shield-Arc Jr.'* They're equipped with 'Job Selector' which can be set for any TYPE of arc and with Current Control which can be set for any arc INTENSITY. Each is *continuous* in selection and self-indicating. I'm *sure* to get the *exact* arc I need to get first place in every welding event.

"Put us on your team and watch us win profitable points and help you set new records in design, manufacturing and construction. Yours for Progress.

"FLEETWELD ROD"

World's Fastest, Most Versatile Welding Performer—For Sale by

THE LINCOLN ELECTRIC COMPANY,
Cleveland, Ohio.

Largest Manufacturers of Arc Welding Equipment in the World.

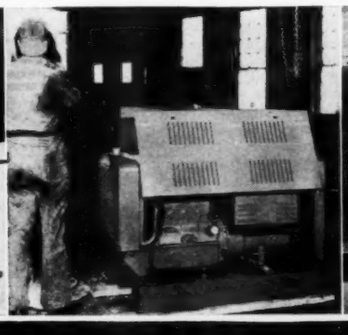
P. S.—See me perform at the OIL SHOW.

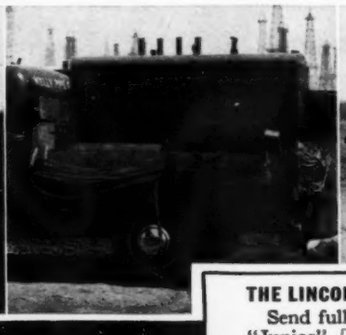
NEW LOW PRICE. In line with Lincoln's policy of ever reducing the cost of welding, this Company has recently lowered prices of welders, electrodes and supplies. Write for new price lists.

VALUE RECORD-BREAKER. The new engine-driven *"Shield-Arc Jr."* 200 amp. capacity.—Price $430. Weighs less than 900 lbs. Occupies floor space less than 8 sq. ft. Never before such big performance for such little price.

SPEED KING of pipe line builders are the heavy-duty *"Shield-Arc"* welders—gas engine and diesel engine types. They've set records in every domestic and foreign field. In ratings of 200, 300 and 400 amps.

PIPE BUILDER'S DOZEN. Twelve 200-amp. *"Shield-Arc* Special" Welders on one truck going to a pipe line job in Kansas. These Lincolns are world's most popular all-purpose, moderate-priced welder.





LINCOLN *"SHIELD-ARC"* WELDERS

The *head line* for profits on the welding front

THE LINCOLN ELECTRIC CO., Dept. AC-27, Cleveland, Ohio

Send full data on engine driven welders ☐ 200-amp. "Junior" ☐ 200-amp. "Special" ☐ *"Shield-Arc."*
Send free bulletin on welding of ☐ Pipe lines ☐ Tool joints ☐ Casing.

Name _____ Position _____

Company _____

Address _____

City _____ State _____

Activities in the Oil Fields

A NEW discovery northwest of Arkansas City and east of Geuda Springs, in Cowley County, Kansas, is W. M. McKnab et al's No. 1 Dr. H. L. Snyder, in NW 15-34-3e. After a 60-qt. shot, the well flowed 231 bbl. per day from the Bartlesville sand at an approximate depth of 3200 ft.

●

Failing to shut-off water in the Hunton lime, Pawnee Royalty Company's No. 1 Boice, discovery in C NE NE of 18-1n-16e, near Falls City, Richardson County, Nebraska, will be abandoned and another well drilled by the company on the same lease. After an acid treatment several months ago, the well pumped and flowed 100 bbl. of oil and 300 bbl. of water. Cavings in the hole interfered with collection of the $15,000 to be awarded to the first well in the state producing 50 bbl. of oil daily for 60 days.

●

A new Pettus sand discovery in Jim Hogg County, southwest Texas, Achning and Daubert's No. 1 Wood, in survey 82, is flowing 125 bbl. per day of 28° A.P.I. gravity oil through a 5/16-in. choke with 480-lb. casing pressure and 300-lb. tubing pressure. The producing formation is at depths of 2603 to 2613 ft. The well is more than 3 mi. west of the old Randado field.

●

Another oil pool was opened recently in the Fouke area of Miller County, Arkansas, when Standard Oil Company of Louisiana's No. 1 Sturgis, in section 1-17-27, was completed as a producer.

The well was plugged-back from a total depth of 9550 ft. to 3786 ft. and the 7-in. casing was perforated with 100 bullets between 3576 and 3606 ft. After swabbing, the well flowed 20 bbl. of oil and 6 percent wash water in 1 hr. In the second hr., the well produced 42 bbl. of oil and 4 percent wash water, flowing through a ¼-in. choke.

●

Pure Oil Company's No. 1 Aldridge, in C E½ NE NW of 17-5s-10e, southern Jasper County, Illinois, recently opened a new field by flowing 1422 bbl. in 24 hr. from the McCloskey limestone at a depth of 2880 ft. The new well is between the Boos and Dundas pools.

●

Devonian production in Illinois continues to be significant, as in the recent outpost well, W. C. McBride Oil Company's test in C W½ SW SE of 35-2n-1w, in Clinton County, which extended the Devonian in the Centralia field one mile north. Flowing 70 bbl. per day naturally, after a 5000-gal. acid treatment, the well flowed 350 bbl. per hr. for 3 hr., then, after being shut-in overnight, flowed 450 bbl. an hr. for 5 hr. before being shut-in to await additional storage.

●

A new pool in southwest Andrews County, Texas, was recently opened by completion of Helmerich and Payne, and Atlantic Refining Company's No. 1 University well, in section 11-11-U, swabbing 8 bbl. of oil per hr. from a depth of 4425 ft. following an 8000-gal. acid treatment.

●

A new shallow pool in Pontotoc County, Oklahoma, was opened recently by Kerlyn Oil Company's wildcat well in the NE of section 26-5-6. The well produced 40 bbl. of oil and 7,000,000 cu. ft. of gas in 24 hr. after plugging back from 2007 ft. to 1901 ft. and setting 5-in. casing at a depth of 1860 ft.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.12-1.38
Playa Del Rey	.65-1.08
Coalinga	.60- .82
Wilmington	.64-1.14
Montana	.90-1.10
Wyoming	.35-1.80
Colorado	.90- .98
New Mexico	.53- .95
Texas	
North Central	.71-1.03
Panhandle	.67- .96
West Texas	.53- .95
Gulf Coast	.86-1.28
Darst Creek	.96
East Texas	1.10
Talco	.65
Kansas	.60-1.10
Oklahoma	.60-1.10
Arkansas	.73-1.05
Louisiana	
Rodessa	$1.05
Gulf Coast	.79-1.28
North Louisiana	.73-1.05
Illinois	.95-1.05
Kentucky	.90-1.10
Indiana	.95
Ohio	
Lima	.90
Michigan	.74-.97½
Pennsylvania	
Bradford	2.50
Southwest	2.15
Eureka	2.09
Buckeye	2.05
Corning	1.12
Canada	2.10-2.17

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

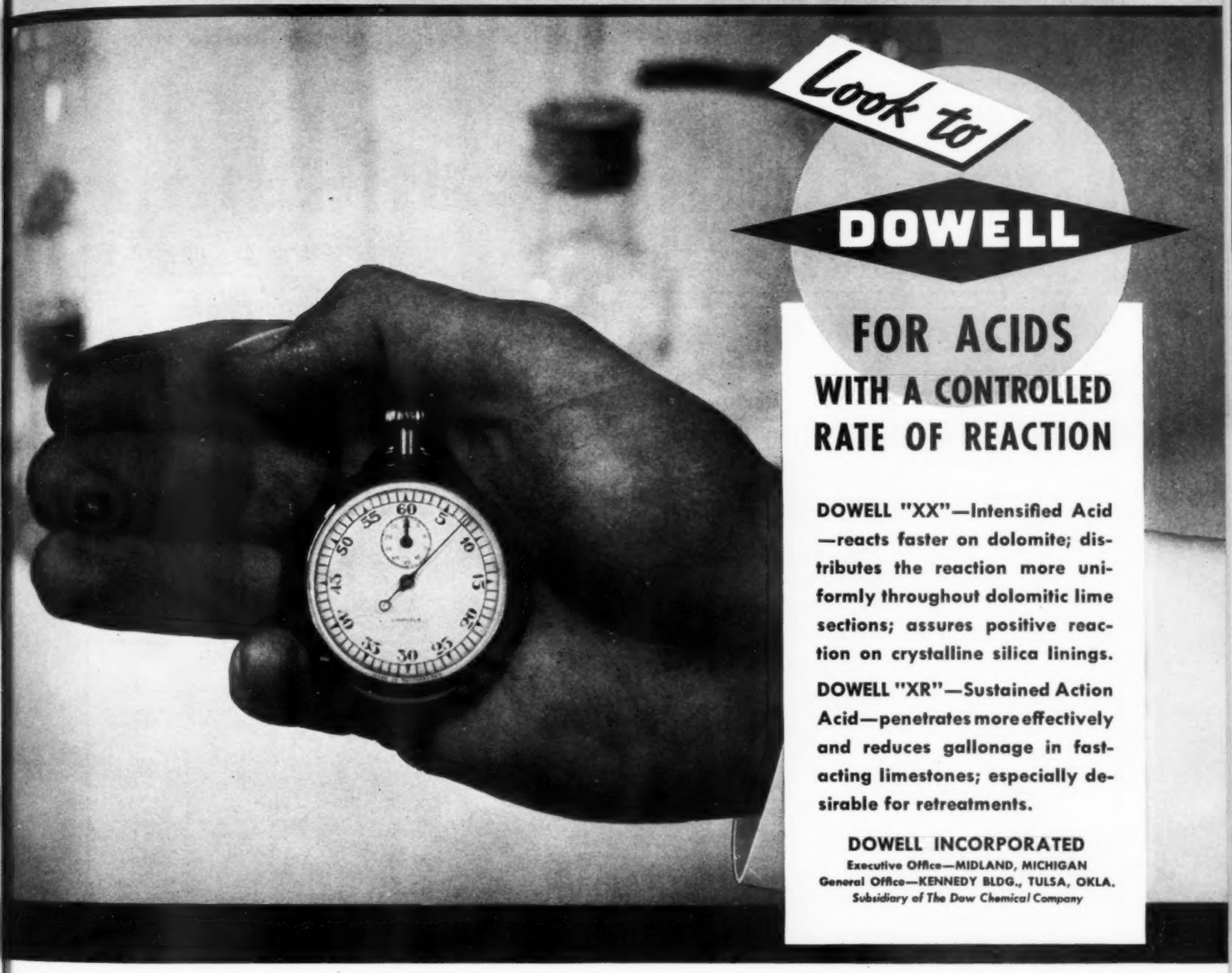
(Figures in bbl. of 42 gal. each)

	[1]B. of M. Calculated Requirements (June)	Week Ended June 1, 1940	Week Ended May 4, 1940	Week Ended June 3, 1939
Oklahoma	408,600	[2]422,350	409,350	445,150
Kansas	159,000	[2]158,850	147,650	156,800
Nebraska	.....	[2] 100	.....	.....
Panhandle Texas	.....	67,450	77,550	75,100
North Texas	.....	104,550	102,600	83,550
West Central Texas	.....	32,550	33,050	31,650
West Texas	.....	236,750	233,300	284,900
East Central Texas	.....	79,050	80,900	97,950
East Texas	.....	396,600	396,650	447,000
Southwest Texas	.....	219,350	214,100	259,650
Coastal Texas	.....	228,250	229,650	235,500
TOTAL TEXAS	1,344,600	1,364,550	1,367,800	1,465,300
North Louisiana	.....	70,100	69,500	73,600
Coastal Louisiana	.....	237,950	224,500	191,900
TOTAL LOUISIANA	274,700	308,050	294,000	265,500
Arkansas	66,700	71,900	69,100	56,350
Mississippi	7,000	[2] 9,350	7,800	.....
Illinois	395,600	449,600	421,550	217,000
Indiana	8,000	[2] 11,900	9,600	96,300
Eastern (not incl. Ill. and Ind.)	98,400	98,900	100,400	
Michigan	62,000	59,150	62,250	64,150
Wyoming	73,000	72,200	66,400	55,300
Montana	18,300	17,900	17,500	14,600
Colorado	4,000	3,300	3,750	3,800
New Mexico	106,700	107,350	106,800	110,550
TOTAL EAST OF CALIFORNIA	3,026,600	3,155,450	3,083,950	2,950,800
California	593,700	593,600	595,100	608,000
TOTAL U. S.	3,620,300	3,749,050	3,679,050	3,558,800

[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of May. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 a. m., May 29.

Timed Acidizing Gets Results



Look to

DOWELL

FOR ACIDS WITH A CONTROLLED RATE OF REACTION

DOWELL "XX"—Intensified Acid—reacts faster on dolomite; distributes the reaction more uniformly throughout dolomitic lime sections; assures positive reaction on crystalline silica linings.

DOWELL "XR"—Sustained Action Acid—penetrates more effectively and reduces gallonage in fast-acting limestones; especially desirable for retreatments.

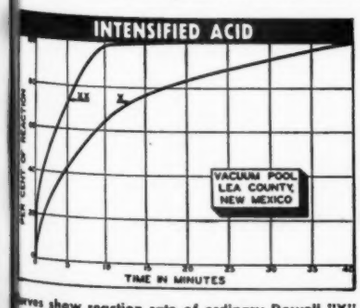
DOWELL INCORPORATED
Executive Office—MIDLAND, MICHIGAN
General Office—KENNEDY BLDG., TULSA, OKLA.
Subsidiary of The Dow Chemical Company

ACIDS with a controlled rate of reaction are never the result of simply mixing a concoction in a test tube. Years of research in the laboratory and in the field are necessary in order to develop them. Dowell "XX" *Intensified* Acid and Dowell "XR" *Sustained Action* Acid are excellent examples of this orderly procedure in scientific development.

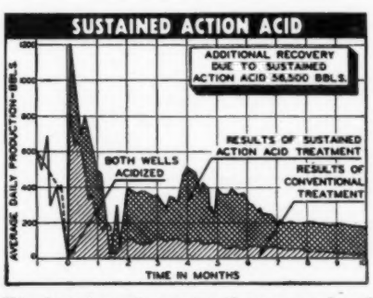
Early treatments determined that impure limestones, dolomites and dolomitic limestones would not react properly with ordinary inhibited acid. Therefore, Dowell developed certain intensifying agents which acted as catalysts and speeded the rate of reaction. The results have been amazing—immense additional quantities of oil have been recovered. Thus, Intensified Acid—Dowell "XX"—has become an invaluable formula in successful acidizing.

For greater effective penetration with less gallonage in fast acting limestones, Dowell developed retarding agents for addition to *Inhibited* Acid. A slower reaction rate, a greater penetrating depth and an increase in permeability resulted. Thus Sustained Action Acid—Dowell "XR"—was born.

The friendly cooperative attitude on the part of oil men and the great technical ability of The Dow Chemical Company, Dowell's parent organization, are weighty factors in these important developments. They provide Dowell with a combination of skill and knowledge that is unsurpassed in any branch of American industry.



...rves show reaction rate of ordinary Dowell "X" ...producing formation of Vacuum Pool, New ...xico, compared with reaction of Dowell "XX" ...nsified Acid.


SUSTAINED ACTION ACID
ADDITIONAL RECOVERY DUE TO SUSTAINED ACTION ACID 34,300 BBLS.
BOTH WELLS ACIDIZED
RESULTS OF SUSTAINED ACTION ACID TREATMENT
RESULTS OF CONVENTIONAL TREATMENT
AVERAGE DAILY PRODUCTION-BBLS.
TIME IN MONTHS

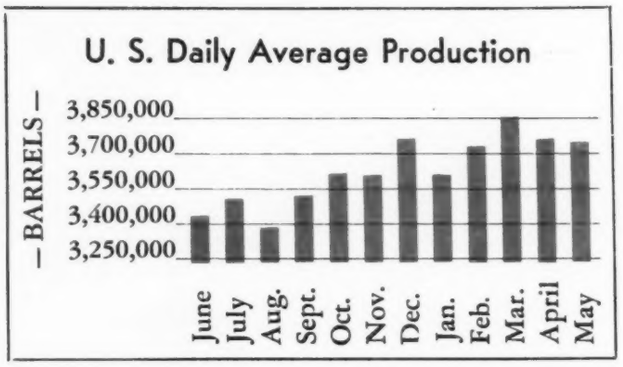
This chart shows the greater oil recovery value of Dowell "XR"—Sustained Action Acid, when compared with treatments using ordinary acid.

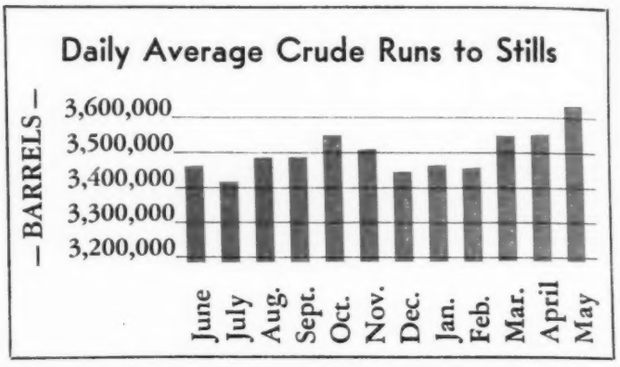
DOW SERVES THE NATION WITH CHEMICAL PRODUCTS

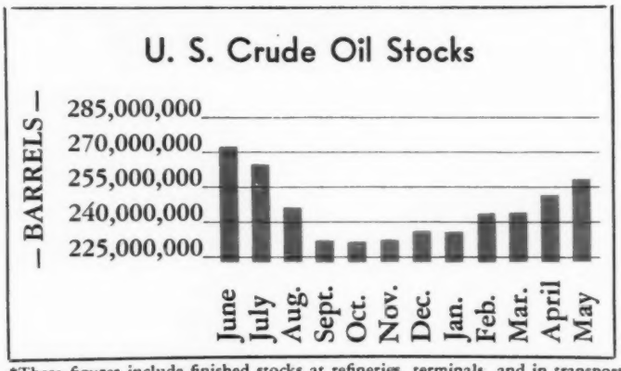
For example: Dow is playing a large part in modern methods of processing leathers by its development of DOWICIDES and other chemical products now regarded as indispensable in this industry.*

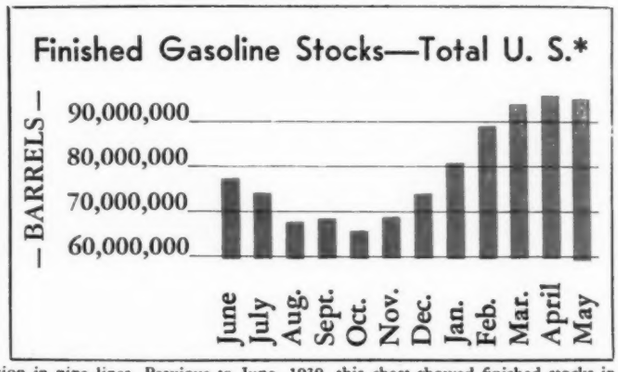
*Trade Mark Reg. U. S. Pat. Off.

Petroleum Statistics and Field Activities









*These figures include finished stocks at refineries, terminals, and in transportation in pipe lines. Previous to June, 1939, this chart showed finished stocks in refineries only. Above statistics by the American Petroleum Institute.

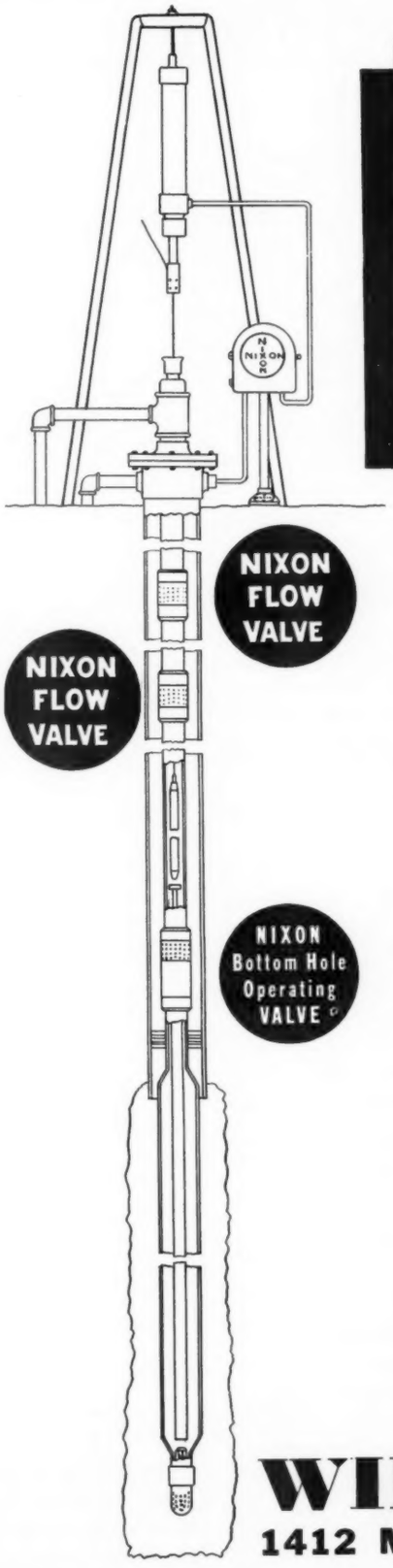
Summarized Operations in Active Fields for May, 1940

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
East Texas	26	24	7	13	3500-3700	2	40	Rotary
Duval County	28	19	7	17	1554-2900	2	22	Rotary
Ector County	43	42	23	72	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	54	53	12	50	1700-3900	2	40	Rotary
Refugio County	8	6	2	5	4900-5900	2	38	Rotary
Nueces County	13	10	2	6	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	43	42	33	48	3730-3935	2	42-43	Rot.-Cab.
Oklahoma								
Fitts Pool	15	14	3	5	1800-4488	2 or 3	38	Rotary
Kansas								
Russell County	30	28	10	25	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	22	14	6	22	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	31	25	5	23	3290-3518	2	39-42	Rot.-Cab.
Illinois								
Central Illinois	346	299	250	139	1425-4100	2	36-38	Rot.-Cab.
New Mexico								
Lea County	30	30	18	45	3150-4030	3	30-34	Rot.-Cab.
California								
Kettleman Hills	10	10	1	12	8300-8730	3 or 4	40	Rotary
Wilmington	20	19	5	12	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for May, 1940

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1939 (In Barrels)
	May	April	May	April	May	April	May	April	May	April	
Arkansas	14	16	9	14	18	10	4	5	29	32	21,266,994
California	137	113	126	101	131	87	83	72	180	184	224,336,682
Colorado	....	....	....	....	....	....	2	0	25	19	1,402,599
Illinois	346	287	299	255	490	155	250	254	139	136	92,915,620
Indiana	33	26	11	18	....	....	7	3	63	59	1,426,000
Kansas	204	162	151	119	234	196	45	42	249	179	59,952,340
Kentucky	66	6	59	5	....	....	8	7	81	88	5,611,500
Louisiana	159	124	131	106	221	98	43	37	189	195	94,110,736
Michigan	104	74	60	63	101	82	54	59	172	175	23,185,203
Mississippi	27	16	12	9	....	....	8	5	29	19	102,918
Montana	22	13	22	12	....	....	5	6	41	31	5,901,058
New Mexico	55	64	46	60	72	44	26	28	138	146	37,453,117
New York	95*	86*	94*	80*	....	....	20	21	73	72	5,105,000
Ohio	95*	44*	75*	19*	....	....	57	47	171	156	3,157,500
Oklahoma	188	183	122	143	188	156	55	59	309	302	156,421,939
Pennsylvania	288*	184*	285*	167*	....	....	....	....	....	....	17,342,500
Tennessee	1	0	0	0	....	....	....	....	....	....	....
Texas	967	787	743	548	1365	1081	411	452	1387	1415	485,847,999
West Virginia	51	29	43	21	....	21	19	24	99	109	3,556,500
Wyoming	8	10	7	10	....	....	12	5	59	48	21,408,478
Total	2860	2224	2295	1750	2820	1930	1109	1126	3433	3365	1,260,504,683

*Includes water-intake and pressure wells.



.. how many flow levels has a well?

Necessity and economy dictate the different levels from which to flow your well during its productive life. How many, and at what depth depend on the nature of the well.

Faced with such facts, sound efficiency and economy demand the installation of the Nixon Surface Control Gas-Lift System. By its exclusive and patented method of setting a series of surface controlled flow valves in the tubing, *at the time of installation,* you can flow from any level, top to off-bottom—WITHOUT PULLING THE TUBING OR CHANGING, IN ANY WAY, THE SUB-SURFACE EQUIPMENT.

Each succeedingly lower flow valve is placed in operation by lowering the weight bar to the valve at that level. This is done by letting out the weight bar wire line at its point of anchorage on the weight cylinder piston rod.

Remember, you can get this type of installation only with the Nixon System. Remember, too, it means a big saving in fluid-lifting cost, reworking, or the purchase and installation of equipment to deplete the well. Talk to a Nixon Gas-Lift Engineer NOW. Write your nearest Wilson Supply Company store or sales office.

WILSON SUPPLY CO.

1412 MAURY ST. HOUSTON, TEXAS

EXCLUSIVE GULF COAST DISTRIBUTORS FOR: Wilson-Snyder Pumps; American Cable Tru-Lay Pre-formed Wire Rope; Kewanee Boilers; Sievers Reamers; Drift Meter, Jr., Gray Swivel; Nixon Surface Control Gas Lift; Nixon True-Taper Slip and Spider; Bowen Pack-Off and Releasing Drill Pipe Overshot; Douglas Weight Indicator; Coffey Robot Stack Draft.

OIL & GAS WELL SUPPLIES

Complete line of
Fishing Tools and Service

BRANCH STORES:
TEXAS: Gladewater; Barbers Hill; Bay City; Monahans; Alice; Victoria; Corpus Christi.
LOUISIANA: Rodessa; Lake Charles; New Iberia; Gretna; Shreveport.
ARKANSAS: Magnolia.
SALES OFFICES: Tulsa, Okla.; Dallas, Texas. Los Angeles: Phone W.L.A. 3-4040.

Activities in Refining

Percent Refining Capacity Operated

Western Division, 79.9 Percent **Central Division, 81.5** **Eastern Division, 87.2 Percent**

THE Pure Oil Company has announced plans to enlarge facilities at its Smith's Bluff refinery on the Texas Gulf Coast for the manufacture of high-octane motor fuel and airplane gasoline. A new polymerization unit will be constructed, to be completed early in 1941. Officials of Pure say this will improve the company's position to fill export requirements for high-octane gasoline.

●

Lockhart Oil Company's recycling plant in the Agua Dulce field, near Corpus Christi, Texas, has been increased considerably since its completion several months ago. Designed for production of 25,000 gal. of distillate per day, this plant, which employs high-pressure absorption, is now manufacturing 35,000 gal. per day. Extraction efficiency is high, operators of the plant report, a contributing factor being the reabsorption of vent tank vapors.

This plant was designed by Petroleum Engineering, Inc., Tulsa, Okla., and is operating under a license from the Distillate Engineering and Processes Company.

●

Magnolia Petroleum Company announced early this month that the capacity of its Fort Worth, Texas, refinery would be increased to 20,080 bbl. per day from 5,500 bbl. The modernization program will involve the expenditure of $2,000,000 and is expected to be completed in about eight months.

●

The Bareco Oil Company is improving its refineries at Barnsdall, Oklahoma, and Wichita, Kansas, it is announced by O. L. Cordell, president. The company is installing at Barnsdall water cooling towers and already has installed a high-melting wax plant. To replace an old unit at Wichita, a new atmospheric distillation crude oil skimming unit is being erected. The total cost of these improvements is from $180,000 to $195,000.

●

The way being cleared after a hearing before the Texas Railroad Commission, Hamman Exploration Company plans to construct a recycling plant in the Hamman field, Matagorda County, Texas. Royalty and landowners had protested the classification of a group of wells as gas wells, but after Dr. F. V. L. Patten, director of production, had explained the conservation benefits derived from such operations in other fields, the objections were withdrawn.

Hamman Exploration Company owns 19 of the 25 producing wells in the field. The plant will process 20,000,000 cu. ft. of gas per day and the residue will be utilized to repressure the producing formations.

●

Gasoline Production Company's recycling plant in the Grapeland field, Texas, is nearing completion and is expected to go into operation before the end of the month. Good weather has contributed to the rapid progress made in the construction of this project.

This plant is being built by Zachry Construction Company of San Antonio, Texas, under a license from Distillate Engineering and Processes Company.

●

Talco Asphalt and Refining Company, a co-partnership heretofore composed of D. H. Byrd, Jack Frost, J. F. Lucey and Ralph E. Fair, has been dissolved, and the business heretofore conducted by this co-partnership has been acquired by Talco Asphalt and Refining Company, a corporation incorporated under the laws of the State of Texas, which will henceforth conduct the business under the same name.

●

Officials of the Alberta Petroleum Association say two *iso*-octane plants, one in eastern and one in western Canada, are contemplated. It is believed that with these facilities the Turner Valley field alone could produce sufficient aviation gasoline to fill the requirements of the empire air-training plan.

●

Announcement has been made by officials of the Union Oil Company of California that additional facilities will be constructed at its Los Angeles refinery beginning about July 1. A new catalytic cracking unit will be installed to produce gasoline of a high anti-knock quality.

Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended June 1, 1940
A.P.I. Figures
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Average Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	585	91.0	23,603	16,261
Appalachian	91.0	115	81.0	3,862	986
Ind., Ill., Ky.	89.5	556	89.7	17,586	6,414
Okla., Kans., Mo.	76.9	285	88.2	8,050	3,096
Inland Texas	59.6	117	70.1	2,016	1,802
Texas Gulf	85.3	878	96.1	14,847	9,670
La. Gulf	97.6	128	80.0	2,883	1,862
No. La. and Ark.	51.5	38	73.1	556	706
Rocky Mt.	55.5	59	89.4	1,639	768
California	87.3	514	70.4	18,251	89,126
Reported	85.1	3,275	85.8	93,293	130,591
Estimated Unreported	.....	375	.....	7,060	3,610
*EST'D TOTAL U. S. JUNE 1, 1940	.....	3,650	.....	100,353	134,301
*EST'D TOTAL U. S. MAY 25, 1940	.....	3,580	.....	100,297	132,371
U. S. B. OF M. *JUNE 1, 1939	.....	**3,423	.....	84,070	139,231

*Estimated U. S. Bureau of Mines' basis.
**May-June, 1939, daily average.

P 425.26

THE Petroleum Engineer

JUNE, 1940

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Rate of Penetration in Drilling

A general discussion of some of the factors recognized as important in their effect on the rate of penetration in rotary drilling.

By K. C. SCLATER
Editor

RATE of penetration is an important item of cost in rotary drilling. It becomes even more important as well depths increase. Not only does it enter largely into drilling costs, it has also an important influence on the proper completion of the well. Thus, because of its economic significance and its influence on the practical aspects of drilling, rate of penetration has become a major topic of investigation and discussion. So far, investigations have been confined largely to an analysis of drilling records. One rather comprehensive survey has been made of the different factors that govern the rate of penetration and an attempt made to determine their relative importance. It is found that the factors affecting rate of penetration are so many and variable that it renders the determination of an efficient rate of penetration a somewhat elusive problem. There are many intangibles that cannot be evaluated. Nevertheless, many interesting facts have been disclosed that throw light on the remarkable progress made during recent years in speeding up the rate of penetration in rotary drilling.

A study of well records shows that during the 6-year period, 1932 to 1938, the total increase in rate of penetration in a group of more than 500 rotary wells in different fields was 123.7 percent.[1] This group of wells was chosen from typical fields in Texas, Louisiana, New Mexico, Oklahoma, Kansas, Wyoming, and California. Records kept on a group of wells in western Kansas show that the drilling time per well, including rigging-up and tearing down the rotary, had been reduced from 39 days in 1934 to 29½ days in 1935, to 20 days in 1936, and finally to 19 days in 1938.[2]

Of the many factors that affect the rate of penetration in drilling and considered important enough to warrant investigation are:

- The character of the formations being drilled
- The type of equipment used
- Rotating speed employed
- Volume and character of drilling fluid
- Personnel.

These factors take into account such things as underground conditions, rig machinery, drill pipe, drilling bits, mud fluid and its characteristics, rotating speeds used, weight on bit, and the efficiency of the personnel, or drilling crew.

Evaluation of these factors to determine their relative importance is an initial phase of the problem of improving rate of penetration on which some thought has been expended.

From the survey made by Brantly and Clayton[1] four factors were investigated. The respective percentages contributing to the total increase in rate of penetration of 123.7 percent in the group of wells studied were reported as follows:

Personnel and equipment	55.5 percent
Rotating speed	39.6 percent
Drilling fluid, volume	28.6 percent

In these figures are included another factor, weight on the bit, which was found difficult to evaluate separately. It should be noted that the percentages shown are merely intended to suggest the importance of the parts played by the several factors in increasing the rate of penetration in the group of more than 500 wells whose drilling records were studied.

The percentage of the increase of 55.5 percent attributed to the two factors, personnel and equipment, was believed to result from—in the case of the personnel—the well-drilling operations passing from rule-of-thumb methods to practices based on sound engineering and technical considerations, and—in the case of equipment—to improvements in bits, their material and design, better methods of using drill pipe, and to improvements in metal and joints of the drill pipe.

As regards the other two factors, rotating speed and volume of drilling fluid, the data studied indicated that, when the rotating speed was increased beyond a certain critical rate, a corresponding increase in fluid volume and weight on bit was necessary in order to maintain a proportional increase in rate of penetration. That is, in drilling with rock bits in "relatively soft nonplastic strata, a 10⅝-in. bit through which 750 gal. per min. of drilling fluid is passed, and on which 6 or 8 tons of weight is carried, will increase in rate of penetration as a straight-line curve to about 200 r.p.m. If the fluid volume is increased to 860 gal. per min. and the weight on the bit to 8 or 10 tons, the rate of penetration will continue to increase as a straight-line curve to a speed of 350 to 400 r.p.m."

The estimated relative importance of the personnel factor was based on

[1] "A Preliminary Evaluation of Factors Controlling Rate of Penetration in Rotary Drilling," by J. E. Brantly and Edgar H. Clayton. *A.P.I. Drilling and Production Practice, 1939.*

[2] See discussion by P. H. Bohart, p. 19, *A.P.I. Drilling and Production Practice, 1939.*

studies of 14 chosen wells, which showed an increase in rate of penetration per hour over the entire period of drilling from the beginning of the first well to the completion of the last well. Obviously the skill of the drilling crew is important. A thoroughly trained and skillful personnel will produce much more efficient results than one less trained and skilled.

One fact that has contributed greatly to the improvement in rate of penetration in rotary drilling is the increased trend toward the instrumentation of the drilling rigs. Such instruments as combination weight indicators, tachometers, odometers, torque instruments, and rate-of-penetration recorders[3] are employed in rotary drilling. The latest of these instruments to be introduced is the rate-of-penetration-recorder. Its introduction has stimulated investigation of factors controlling the rate of penetration.

The type of formations penetrated is one factor that varies widely, not only from field to field, but from well to well. Hardness or softness of the formations will not only influence drilling but also the frequency of changes from hard to soft formation or vice versa, encountered in the course of drilling. The presence of heaving shale in a well might greatly retard the rate of penetration. Evidence of how this would influence drilling speed is seen in the fact that heaving shale has increased the cost of many a well three- or four-fold. Obviously, in areas where heaving shale is encountered, evaluating the effect of the formation on rate of penetration may prove futile.

Equipment as a factor affecting the rate of penetration lends itself to more exact appraisal, especially where drilling conditions are normal and reasonably uniform. Size of bit and the type of bit are important. The size of bit is usually governed by the casing program, the type of bit by the formations to be penetrated. In deep wells pulling the drill pipe to change a bit because of a change in formation may not always be justified, hence certain sections of formation may be penetrated with a bit that is not the most suitable.

One of the most important factors is the weight on the bit. In this connection the skill of personnel plays a large part. The speed of rotation must also be considered in relation to the weight on the bit. At the present time, there is some divergence of opinion on rotating speeds. Speeds as high as 750 r.p.m. have been successfully used in California. The conditions there are more favorable to high rotating speeds than in many other areas.

Brantly and Clayton's[1] observations indicate upper practical limits of rotating speeds of 350-400 r.p.m. for reasonably deep holes. Recently speeds as high as 750 r.p.m. have been used in California.[4] Weight on the bit and rotating speed cannot be considered separately. One is a function of the other. The rotating speed in turn is governed by the equipment used, its capacity and design. It is found that at high rotating speeds there are critical limits within which vibration in the drill stem or in the surface equipment is excessive. This critical limit may, in some cases, be exceeded and trouble from this source removed.[4] In other cases, increasing the rotating speed will result in destruction. This limitation has to do with design chiefly, and is one that can be removed by improvements in design to meet the higher rotating speeds, toward which there seems to be a distinct trend. It was found in one field that increasing weight on the bit and maintaining the same rotating speed gave no appreciable increase in penetration, but increasing the speed of rotation increased the rate of penetration almost in direct proportion to increased speed of rotation. Also for twice the usual weight on the bit the rate of penetration was increased and a straight hole obtained.[1] It should be noted that Brantly and Clayton's survey included wells in which no attention was paid to proper table speeds, weight on the bit, fluid volume, or increased efficiency of personnel and equipment. Where attention was paid to these factors and up-to-date methods used the increase in rate of penetration was as great as 400 percent.

In general, it is found that at slow rotating speeds the cuttings are coarse and become less coarse as the speed is increased. In certain lime areas it has also been observed that excessive rotating speed is detrimental to drill pipe life and that the critical speed limits are quite low compared with other areas.

From the data that have already been made available on investigations of this kind it is desirable to put the results into a form for practical use, in order to facilitate their application by the man on the derrick floor. In making evaluations of the factors affecting rate of penetration it is well to keep in mind the area and the purpose for which the information is to be used. Unless this is kept sight of there may be a tendency to over-emphasize ultra-technical details out of all proportion to their relative importance.

There are certain fundamentals that can be kept in mind with respect to each factor that can be applied as a guide in further work. Too much emphasis on any one factor is to be guarded against. As has been stated by Bohart,[2] "the maximum penetration is reached only when all factors are in proper balance. This condition can be obtained only by close observation and diligent application by those responsible for the work in each locality, and the conclusion inevitably is arrived at that well-trained and carefully-selected personnel has made possible very much faster drilling time in recent years."

There are fundamental factors with regard to equipment that are of general application. Among these is the selection of the equipment for the conditions encountered, such as long drill collars in the drill stem sufficient to obtain adequate weight on the bit and maintain tension in the rest of the drill stem while drilling is in progress.

Certain fundamentals regarding drilling fluid are important. Mud fluid can be considered from two angles, quantity and quality. Well conditions may be such that a certain type of mud may be necessary to control well conditions but may impede the rate of penetration. It has been found also that the viscosity of the mud sometimes has a bearing on the speed of rotation. At extremely high speeds the viscosity of the mud is essential.[4] The volume of mud is also an important item in high-speed drilling for keeping the bit cool and maintaining the cutting efficiency of the bit.[4]

In drilling a well, efforts to increase the rate of penetration should not be attained at the expense of any one or group of factors. Even though a high rotating speed may in certain cases give a greater rate of penetration there might be well conditions that preclude the advisability of using such rotating speed. The careful driller is always on guard against accidents. He realizes that straining the equipment and materials with which he works beyond their endurance may lead to a serious fishing job and possible loss of the hole.

Neither is it to be assumed that the most efficient type of equipment is in use on every well. There may be circumstances that necessitate the use of equipment that is not the best available. A drilling contractor who is obliged to keep his tools running 100 percent of the time must keep them in good repair. Before considering their replacement he must give thought to the probabilities of keeping them in continuous operation. Idle drilling equipment is not desirable.

[3] "Record of Penetration Rate Should Aid in Drilling-Time Studies," by H. Lee Flood, *The Petroleum Engineer*, October, 1939.

[4] "High Rotary Speeds in California Drilling," by Wallace A. Sawdon, *The Petroleum Engineer*, March, 1940.

The Technology of Refining Processes

Article 6

TREATING LIGHT DISTILLATES

By

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A biographical sketch and photograph of the author can be found on page 29, May issue of *The Petroleum Engineer* in connection with Article 5 of this series.

THE term "light distillates" will refer in this article only to such light products as are employed in the blending of gasoline and aviation fuels. Normally the word includes kerosine, various types of solvents and cleaning naphthas, and other low-distillation products. The increasingly great economic importance of motor fuels, however, so far outweighs the value of all the other products that in the short space available the discussion shall be confined to reviewing briefly some of the more outstanding treating developments of the last few years that contribute to obtaining better or cheaper gasolines for automotive and aviation use.

For years the sulphur content of gasoline was held down rigidly, chiefly because U. S. Government specifications, in the early twenties, set 0.10 percent as the maximum allowable sulphur content; states adopted these specifications widely, forgetting that the purposes of State and Federal specifications do not coincide at all and that requirements suitable for a purchaser of bulk products such as the Federal Government may be totally unadaptable to the control of average products sold within a state's borders to its citizens. The reason, earlier, for limiting sulphur content was to reduce or eliminate corrosion.

The reasons for reducing sulphur to its lowest practicable percentage now are "economic and not corrosive," as one waggish refiner recently phrased it. The relation between sulphur content and lead susceptibility of motor fuels is close, and may result in high costs if the amount of tetraethyl lead required to bring the octane number of sub-grade gasolines to standard competitive levels is excessive. Because of this, most efforts of technologists during the last few years have been directed toward reduction of sulphur content and improvement of the susceptibility of gasoline to lead additions. Sulphur compounds react adversely in lowering the octane number increase effected by addition of any given amount of lead to the fuel. Hydrogen sulphide is one of the most undesirable compounds in its effect on lead susceptibility, but its removal is simpler than that of many other common sulphur compounds.

Sulphur compounds vary in their effect on knock rating improvement by lead. "Polysulfides are among the worst in this respect," say Yabroff and Nixon *(National Petroleum News,* February 21, 1940, p. R-56. See also "Extraction of Mercaptans with Alkaline Solutions," D. L. Yabroff, *Proc. Am. Chem. Soc.,* April 3-7, 1939), "followed by disulfides and mercaptans, thioethers and thiophenes." The old-established "doctor" sweetening process converted mercaptans into disulphides, with some polysulphides being formed as well by the reaction. The customary skeleton equation for this conversion to disulphides is:

$$PbO + 2H\text{-}S\text{-}C_2H_5 = Pb\langle^{S\text{-}C_2H_5}_{S\text{-}C_2H_5} + H_2O.$$

$$Pb\langle^{S\text{-}C_2H_5}_{S\text{-}C_2H_5} + S =$$

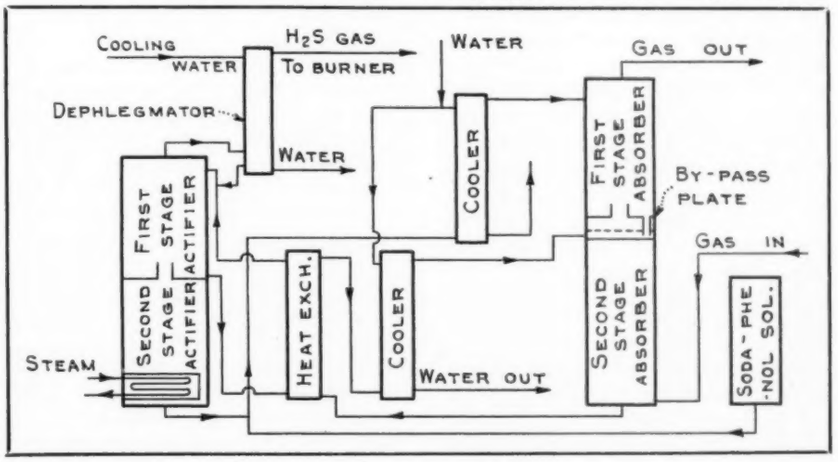
$$\begin{matrix} S-C_2H_5 \\ | \\ S-C_2H_5 \end{matrix} + PbS.$$

(diethyldisulphide)

The lead is used in the form of sodium plumbite, Na_2PbO_2, or NaOH plus PbO. Lead sulphide is formed during the reaction, and the reagent is regenerated by heat and the oxygen of the air blown through it to form the plumbite again for re-use. Free sulphur is added to the mixture of reagent and gasoline to "break" or precipitate the lead sulphide with the result that often the finished, sweetened product contains more sulphur than it did originally, although the sweetened gasoline will pass the "doctor" test and is noncorrosive to the copper strip. Its lead susceptibility has not been increased and in many cases is decreased, adding expense to the process of producing a fuel of the desired octane rating by the addition of lead.

Recently we have become interested in reducing the sulphur content far below that set as maximum by earlier specifications. To illustrate the effect of sulphur on the amount of lead needed, or the octane number effect of a given amount of lead, Schulze and Alden *(Proc. Amer. Pet. Inst.,* 1939) found that 2 cc. of lead added to a natural gasoline containing 0.037 percent sulphur of 67.2 octane number

Fig. 1. Flow diagram of sodium phenolate (Koppers) desulphurizing process



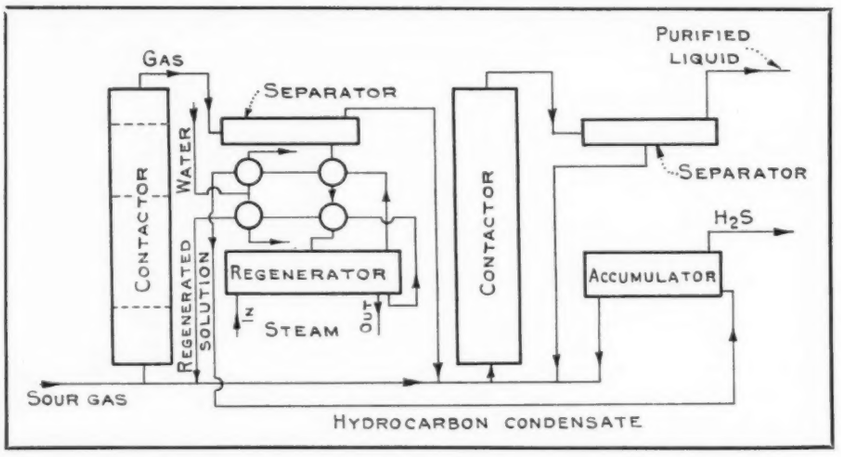


Fig. 2. Flow diagram of two-stage H_2S removal process using tri-potassium phosphate (Shell)

showed a rating of 79.6; reducing sulphur to 0.002 percent gave a rating of 84.9 octane number. Six cc. of lead gave the undesulphurized sample 86.6 octane number, and the desulphurized fuel showed 93.2 rating with the same amount of lead. This improvement saved 62 percent of the lead required to bring the undesulphurized gasoline to 76 octane number and 56 percent of that required to give a rating of 88 octane number for aviation fuel.

Recent developments have shown that the use of caustic solutions for washing raw gasolines containing sulphur, especially in the mercaptan form, gives decidedly advantageous results in lead susceptibility. A six-stage washing with caustic reduced the lead requirements of a Michigan cracked gasoline from 1.32 cc. to 1.11 cc. (Henderson, Ross, and Ridgway, *Proc. Amer. Chem. Soc.*, Sept. 7-8, 1938). Doctor treating the same gasoline gave a product requiring 1.85 cc. to obtain a 70 rating. A gasoline that required 1.7 cc. to give 77 octane number, after caustic washing required only 1.54 cc. Doctor sweetening alone with 100 percent excess free sulphur added during the treatment raised the lead requirement for 77 octane number to 2.2 cc. with the same gasoline, a higher requirement than that for the untreated product.

As a result of the discovery of these facts, caustic washing of naphthas containing appreciable amounts of sulphur has become general. It reduces the sweetening cost appreciably even when higher molecular weight mercaptans are present and the doctor or other sweetening process must also be used to obtain a sweet gasoline. The process is simple, requiring only a series of (preferably) packed columns, the packing of carbon rings or other material that does not react with caustic, with mixers to blend caustic solution and naphtha intimately before the mixture is discharged into the column to separate by gravity. Naphtha and solution flow counter-currently through the system, fresh caustic at one end meeting the naphtha, which has already been contacted in the other columns. Proportions of caustic and naphtha vary, depending on the amount of mercaptan sulphur in the latter, and ranging from a ratio of 1:1 for high-sulphur products to 1:5 for those low in sulphur. The caustic is regenerated by heating and by passing it counter-currently through a bubble tower where steam hydrolyzes the sodium mercaptides, driving off the mercaptan to the air and re-forming the caustic for re-use. The caustic solution is about 15° Be. strength, and the reaction is carried out at slightly elevated temperatures of less than 95° during treating. The spent caustic is rid of mercaptans at the boiling temperature or thereabouts.

Hydrogen sulphide, H_2S, is found especially in gasolines cracked from high-sulphur crudes and is also removed by this process. Sodium sulphide and acid sulphide are formed when caustic is used, however, and therefore the H_2S is usually removed in the stabilizer or by dilute caustic solution, which is then discarded. The sodium sulphide is difficult to hydrolyze with steam and water, and its formation represents a loss of caustic, which increases the cost of the process.

Caustic solutions that have been used and regenerated repeatedly show little reduction in their effectiveness. Caustic washing is said, however, to reduce the induction period of gasolines, apparently removing natural inhibitors present in the unwashed product, so that gum formation begins more quickly. Regenerated solutions show less effect in shortening the induction period; this may be due to the fact that the solution becomes more and more nearly saturated with the various natural impurities present—phenolic and other bodies—and thus dissolves less and less of them after each regeneration.

The "Solutizer" sweetening process perfected by Shell Development Company, and the older but still recent development of the copper chloride or Perco process have both added materially to the technology of sweetening. The Solutizer process uses a solution of 6-normal potassium hydroxide and 3-normal potassium *iso*butyrate, the butyrate being referred to as the solutizer. These processes improve the lead susceptibility of the product by removing the mercaptan sulphur from it, and also either increase the octane number of the fuel "as is" or fail to decrease it at all. The Solutizer process treats the naphtha counter-currently with the potash-*iso*butyrate solution and requires the use of 20 to 60 percent by volume of solution to sweeten most naphthas, the quantity depending on the amount of sulphur present in the raw naphtha.

Treating gasolines showing 0.019 to 0.193 percent by weight of mercaptan sulphur (Yabroff and Nixon, loc. cit.), the octane number of the unleaded sweetened fuels was improved 0.2 to 2.0 octane numbers. One cc. of lead tetraethyl raised the octane numbers of these sweetened fuels by as much as 0.3 for a catalytic polymer naphtha, to 3.2 numbers for a straight-run naphtha. Three cc. of lead gave octane number increases of from 0.7 for the polymer to 4.3 for a straight-run naphtha, or an average improvement for 31 samples of 1.68 octane numbers. The straight-run samples showed the highest improvement in both unleaded octane number and in lead susceptibility. The catalytic polymer showed the lowest improvement. The amount of lead required to raise the sweetened gasoline to the same octane rating as that obtained by 2.0 cc. in the sour gasoline ranges from 0.76 cc. in a cracked naphtha—saving 1.24 cc.—to 1.81 cc. in another highly cracked product, an average for the 31 samples of 1.42 cc., or a saving per gal. of finished gasoline of 0.37 cent.

The copper chloride or Perco process treats sour gasoline with copper chloride solution to remove the mercaptans almost quantitatively. The cupric chloride is reduced to cuprous chloride and hydrochloric acid in the reaction. The solution is regenerated by blowing with air to re-oxidize the chloride to the cupric state. To remove the last traces of copper from the sweetened

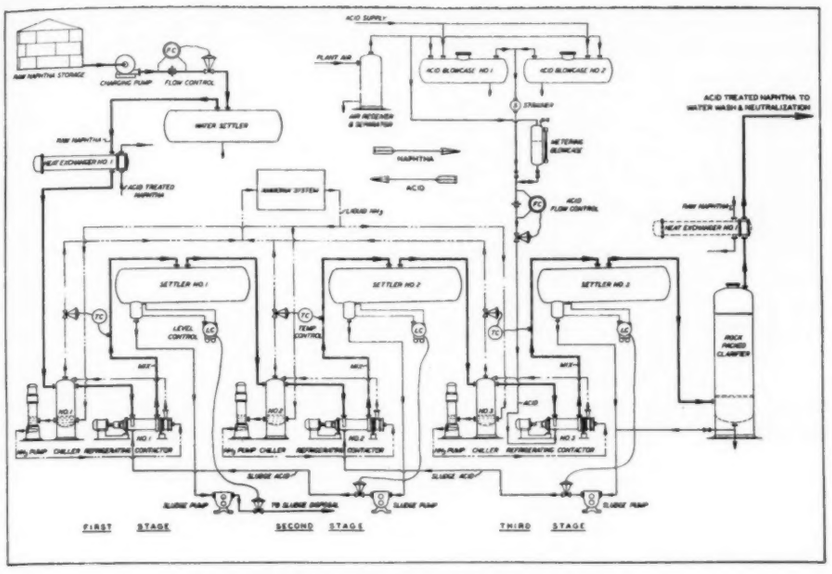


Fig. 3. Flow of Stratcold treating process

gasoline a solution of caustic soda-sodium sulphide is used. Leaving these traces of copper causes the gasoline to discolor rapidly in storage and also increases the rate of gum formation, but this stabilizing wash eliminates this problem. Gasolines so sweetened show either no change in octane number or 0.5 to 1.0 improvement. Doctor-treated gasolines at the same time showed a loss of three to four octane numbers, with a corresponding loss in lead susceptibility as compared to the copper-sweetened product.

The "wet" process described is that usually applied to cracked gasolines. Straight-run gasolines and natural gasolines high in mercaptan sulphur are treated by passing them through towers in contact with a "solid" reagent consisting of a solid carrier such as Fuller's earth impregnated with copper chloride solution. Care must be observed that no caustic reaches this solid reagent, which is packed in the tower supported by any convenient method such as a blanket or mat on a perforated false bottom. H_2S is removed from the gasoline prior to reaching the copper tower by the use of caustic solution. Air is introduced into the tower with the gasoline.

The use of the copper chloride process requires the use of wooden tanks wherever the solution is present, and pumps, etc., must be made of solution-resisting metal or material if it comes in contact with the solution. The treating solution is tested with a calomel half-cell, platinum electrode at intervals to determine its oxidation potential and thereby determine when it must be regenerated. The solid reagent cannot be so checked but the sweetened gasoline is checked regularly, and the reagent is cut out of the system for regeneration when the check results show that its activity has fallen below that required for efficient operation.

The U.O.P. copper sulphate process is similar in principle to that of the chloride just discussed, copper sulphate in solution being the reagent that is reduced to the cuprous state while oxidizing the mercaptan to disulphides. The PbS process employs lead sulphide in a strong caustic solution to oxidize the mercaptans, along with a small proportion of sodium sulphide to form the PbS from the sodium plumbite solution. This reagent is regenerated by controlled amounts of air blown through it, the amount of air ranging to 1 cu. ft. per bbl., depending on the sourness of the stock treated with it.

Adaptation of molecular oxygen to the oxidation of mercaptans in sweetening gasoline has recently been applied in the Hoover process. This method utilizes oxygen with some cupric chloride, it is understood, with Na_2S, sodium sulphide, to complete the job. A large installation has been made recently in a refinery in Kansas, but of the advantages and economy of the process little is known at present.

Catalytic Desulphurization

The most intriguing of the new methods for sweetening and desulphurizing motor fuels are those employing catalysts. These processes not only sweeten the distillate, but in many cases almost completely desulphurize it. Catalysts include bauxite and other "natural" products containing alumina, acid-treated clays impregnated with heavy metal oxides, and other catalysts.

The Houdry catalytic processes include a catalytic treating method, applied in the vapor phase to catalytically or thermally cracked gasolines, and in the liquid phase to catalytically produced aviation fuels. The raw gasoline is vaporized and heated to about 600°F., and the vapors passed at 15 to 100 lb. pressure over a solid catalyst of acid-treated clay mixed with oxides of nickel and of manganese to eliminate the greater portion of the sulphur. The catalyst is regenerated with air at 4-6 hour intervals. (Houdry, Burt, Pew, and Peters, *Proc. A.P.I.*, 1938). Sulphur content of 0.15 to 0.20 percent is reduced to 0.06-0.08 percent. The lead susceptibility is improved by as much as three octane numbers per cc. of lead. Mercaptans and hydrogen sulphide are completely removed and "at least 30 percent of the original total sulphur" as well, it is asserted.

Liquid-phase treatment of aviation fuel reduces the acid number to 10 or lower and yields a fuel with bromine number, sulphur, gum, etc., satisfactory for aviation specifications. The yield by either vapor-phase or liquid-phase methods is of the order of 99 percent from catalytically cracked gasoline; costs are 2.5 to 4.5 cents per bbl. of charge, it is stated.

Refinery and other gases may be almost completely desulphurized by passing them, at temperatures of about 750°F. and at nominal pressure, over a catalyst composed of nickel oxide on an inert solid carrier. The contact period is about 30 minutes, care being taken to eliminate so far as possible the formation of nickel sulphate.

The Perco process for catalytically desulphurizing gasoline employs a "natural" bauxite catalyst, with which the sulphur-bearing naphtha is contacted at low pressure (15 lb.) and 750°F. Two volumes of naphtha may be treated per volume of catalyst, after which the latter must be regenerated by burning with air. This process not only increases the octane number of unleaded fuel but increases its lead susceptibility remarkably. A straight-run gasoline was raised in octane number from 44.8 to 48.1 by reducing the sulphur from 0.425 to 0.011 percent. One cc. of lead increased the untreated product to 50.1 octane number; 1 cc. in the desulphurized gasoline raised its octane number from 48.1 to 63.4, a gain of 15.3 numbers as compared with 5.3 for the untreated product. Three cc. of lead in the raw gasoline raised it to 56 octane number, an increase of 11.2 numbers. The treated material with 2.04 cc. of lead was raised to 70 octane

number, an increase of 21.9 numbers by the lead alone or 25.2 numbers by treating and leading together. High sulphur gasolines after treatment have generally shown at least twice the lead susceptibility of the untreated naphtha. (*National Petroleum News*, Sept. 20, 1939.)

Treating a low-sulphur natural gasoline of 0.037 percent sulphur, 6 cc. of lead are required to raise it from 67 to about 87 octane number. When sulphur is reduced to 0.008 percent, 4 cc. of lead gives 87.6 octane number; reducing the sulphur to 0.002 percent enables the refiner to obtain 87.5 octane number with 3 cc. of lead. Thus more than 60 percent of the lead needed to produce 87-88 octane number aviation naphtha is saved merely by reducing the sulphur content to a negligible figure. (Schulze and Alden, loc. cit.) This desulphurization method is especially advantageous in the refining of high octane number stocks of natural and refinery gasoline for blending with *iso*octane for aviation fuels. These authors state that by desulphurizing a pentane-free natural naphtha its lead susceptibility is so increased that the amount of aviation fuel of 100 octane number that can be made by blending the desulphurized product with 91 octane number *iso*-octane is increased by 27.7 percent, using a maximum of 3 cc. of lead.

Desulphurizing Gases

Three processes have been developed in the last few years for desulphurizing refinery and industrial hydrocarbon gases. These are the Koppers sodium phenolate, the Girbotol, and the Shell phosphate processes. Each warrants some description here, in that all have been used in refineries to some extent, and have proved to be very profitable as means for removing sulphur from gases used in the synthesis of high octane number naphthas by polymerization, hydrogenation, alkylation, and other processes recently devised.

The Koppers process uses sodium hydroxide dissolved in a solution of phenol in water to remove hydrogen sulphide. As temperatures of solutions of H_2S in caustic solution rise, the H_2S tends to be retained by the caustic and to resist decomposition by boiling. The addition of phenol brings into the equation a weak acid that is less acidic than the hydrogen sulphide at lower temperatures, which permits the sodium hydroxide to combine with the H_2S of the gas and thus remove it. When the sulphide-impregnated solution is heated, however, the acidity of the phenol increases slightly faster than that of the sulphide, with the result that the phenol displaces the sulphide, forming sodium phenolate and dispelling the sulphide from the solution.

In a two-stage system the solution contains 4 mols of NaOH, and 2.4 mols of phenol per liter. This is used to treat, by counter-current flow in bubble towers, a gas containing 6000 grains of H_2S per 100 cu. ft., which is discharged from the system with only 80 grains per 100 cu. ft. In the process the raw gas enters the base of the first bubble tower section and passes out at the top. A portion of the down-flowing solution is drawn off midway in the reactifying tower and enters the absorber tower about halfway up. The solution from the bottom of the absorber is returned to the top of the actifying tower, where it is heated with steam to drive off the H_2S absorbed. That part of the solution not drawn off at the midpoint of the actifier flows to the bottom, is stripped of all the H_2S possible to remove, and is returned to the top of the absorber, flowing downward and mingling with the half-actified solution entering the middle of that tower.

This process has been applied to refinery processing, both for "cleaning up" charge stocks to polymerizer and alkylation units, and for the recovery of sulphur, which is converted to sulphuric acid in an auxiliary plant. In one unit 35 tons of sulphuric acid per day is produced by converting the H_2S to acid by the contact process. (*National Petroleum News*, June 1, 1938, p. R-268.)

The Girbotol process utilizes the absorptive capacity of various amines, of the type $C_nH_{2n+1}NH_2$ and $(C_nH_{2n+1})_2NH$, etc., for H_2S, CO_2, and other slightly acidic products from hydrocarbon gases. Pressures vary from a few pounds to 500 lb. or more, and absorber temperatures range from 50 to 160°F. It is desirable to hold temperatures comparatively low, as the absorptive capacity of the water solution of the amines falls off rapidly with increases in temperature above a fairly low value. The acid gas enters an absorber and passes upward against a down-flowing solution of the amine, and leaves the system at the top of this tower after having lost as much as 99 percent of its sulphur. The sulphur-laden solution passes to a regenerator tower fitted with a reboiler where closed steam coils heat the solution to boiling, the generated steam passing into the tower and removing the hydrogen sulphide, sending reactivated solution back to the absorber tower. If dehydration is needed, diethylene glycol instead of water may be used as solvent for the amine, and water thus eliminated from the gases. This latter system is used extensively in the recovery and purification of carbon dioxide for the manufacture of dry ice. The solutions are said to be non-corrosive and no special equipment is required to build or operate the plants.

Solutions of 40-50 percent of tripotassium phosphate are used in the Shell process for absorbing hydrogen sulphide from refinery or other gases. The cheaper grades of potash and phosphoric acid are used in the solution, made by the simple process of dissolving the chemical in water. The raw gas is passed counter-currently through a bubble tower to contact the solution, which flows downward, and the sulphide is absorbed according to the reaction:

$$K_3PO_4 + H_2S = K_2HPO_4 + KHS.$$

The solution from the bottom of the absorber enters a boiler heated either indirectly with exhaust steam or direct-fired, depending on the economies to be obtained from one method or the other. The absorption may be divided into two steps, the concentrated solution being used first on the raw gas, and a more dilute solution being contacted with the partly desulphurized gas that has passed through the first section. This is done for the reason that the partial pressure of H_2S in equilibrium with phosphate solution is lowered by dilution of the solution, and thus a higher percentage of sulphur is removed by the more dilute solution. The gas may be treated at any convenient temperature within reasonable limits, although temperatures to 200°F. may be employed. The higher temperatures are often more advantageous when the purified gas is to be processed later at elevated temperatures.

Liquid hydrocarbons may be robbed of H_2S also by counter-current contact, as the solution is immiscible with hydrocarbon liquids. Plant equipment and arrangement are similar to that used in treating gases, except that pumps suitable for handling liquid instead of gaseous hydrocarbons are used. In treating either gases or liquids the more dilute solution used in the upper section of the absorber is obtained by returning the condensate from the regenerating unit to the top of the absorber tower, along with a portion of the regenerated solution. The major portion of the regenerated solution is returned to the lower, heavy-solution section of the absorber.

EDITOR'S NOTE: The seventh article in this series will discuss "Refining Methods for Lubricating Oils".

Gravel-Packing Injection Wells for Recycling Gas Is Important Phase of Completion

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

Before putting injection wells into operation, they are underreamed and gravel-packed in order to obtain low injection pressures when returning large volumes of gas

By H. LEE FLOOD
Associate Editor

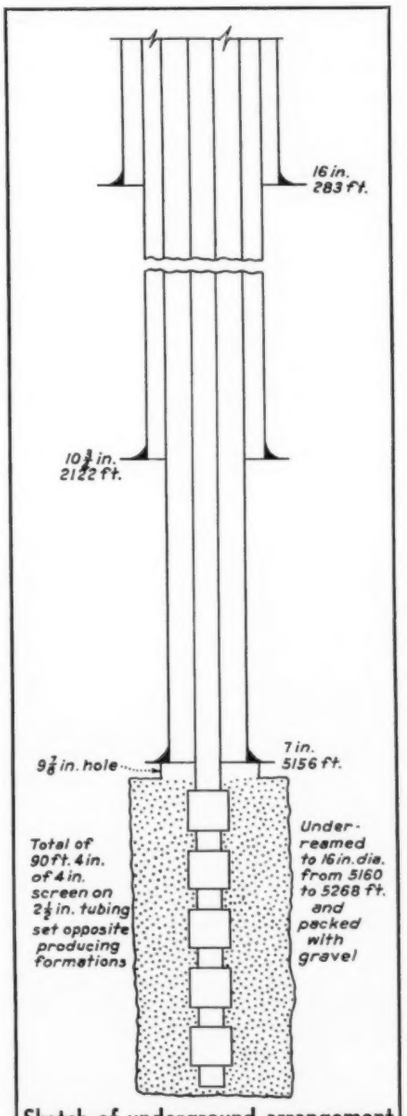
NO OTHER TYPE of oil-field exploitation today captures the interest of production engineers so much as the problem of producing efficiently the condensate reservoirs that have been discovered during the last few years. More is being learned every day about the proper methods by which the reservoir contents should be lifted to the surface, the liquid or condensate extracted, and the stripped gas returned to the reservoir in order to avoid the decline in reservoir pressure that would result in the loss of the condensable fractions underground, to be forever irrecoverable.

Condensate production and recycling, in their day-to-day application, consist of numerous minor problems that must be studied and worked out as they are encountered. In many of these, new methods and approaches must be developed but in others, it is only a matter of adapting practices already known.

An example of the latter type is the application of gravel-packing as a part of the procedure of completing injection wells by one of the leading companies engaged in recycling gas in the Long Lake field, in east central Texas.

Heretofore, gravel packs have been used in producing oil wells and in large water wells in California, on the Gulf Coast, and elsewhere, usually to exclude fine sand and prevents its filling the well bore and damaging the pumping equipment by scoring or abrading the working parts of the pump, cutting out tubing and other piping, etc. Gravel packed around the screen in a well serves to trap fine sand within the interstices of the gravel without seriously interfering with the passage of fluids. Gravel has also proved valuable as a means of filling the cavities at the bottom of a well bore and serving as a structural support for the walls of the hole, thus preventing caving of any loosely consolidated sand and shale that may be present.

In the Long Lake field, the primary consideration that led to the use of gravel-packing in injection wells was the problem of being prepared to return enormous volumes of gas to the reservoir. Briefly, it was desired to reduce the friction losses and pressure drop to as low a figure as possible. It was recognized that the exposed face of the formation at the bottom of an injection well could easily prove to be one of the "bottle necks" in the system if the pressure differential across the sand face were high. It followed, then, that the greater the area of formation face presented to the incoming gas, the lower would be the velocity of the gas into the formation and the pressure drop would likewise be smaller. Greater wall area in a well bore is attained, of course, by increasing the diameter of the hole. The usual way of attaining a greater hole diameter opposite the producing formations in the lower part of a well is by underreaming. Accompanying the advantage of having a larger exposed wall area is the disadvantage of increasing the risk of caving in the hole. It was principally to resist this tendency that the injection wells were gravel-packed.


16 in.
283 ft.
10¾ in.
2122 ft.
9⅞ in. hole
7 in.
5156 ft.
Total of 90 ft. 4 in. of 4 in. screen on 2⅜ in. tubing set opposite producing formations
Under-reamed to 16 in. dia. from 5160 to 5268 ft. and packed with gravel

Sketch of underground arrangement in gravel-packed injection well

Interesting, too, is the fact that the wells were packed with gravel as a part of the initial completion following drilling. Too often, gravel-packing is deferred in wells, even when its need is obvious from the start, and is then resorted to as a remedial measure later.

One of the two wells in the Long Lake field in which gravel was packed was completed in August of last year, the other in December. The first of these will be designated as well A, the second as well B. Both wells are similar in most respects and, except for one or two differences that will be mentioned, the discussion will be confined to well B as being representative of both wells. This is further justified by the fact that well A, although completed as an injection well, has never been used as such but was converted into a producing well.

Underreaming the Hole

An important lesson can be learned from a comparison of the methods by which the two holes were underreamed prior to being packed with gravel.

In well A, the 7-in. O.D. casing was set and cemented before the hole was underreamed so that it was necessary to run and operate the underreamer through the casing. Being thus restricted to the use of no larger than a 6¼-in. body in the underreaming tool, it was found that insufficient strength was present to withstand the strain of underreaming and enlarging the 9⅞-in. hole to a diameter of 16

in. The work was completed with difficulty and then only after a fishing job.

In well B, on the other hand, profiting by the earlier experience, the hole was underreamed before the 7-in. casing was set. Operating in a 9⅞-in. hole, a large enough tool could be used to provide ample strength for underreaming to 16 inches.

It seems unnecessary to stress the importance of deciding beforehand whether underreaming will be necessary, in order to avoid the trouble that has just been described. Yet in many instances, operators continue to make the same mistake of setting casing first and then deciding to underream afterward. When the formations are comparatively soft, as on the Gulf Coast, the matter is not so important. But when the formations are relatively hard, as in the Woodbine as found in the Long Lake field, an effort should be made to anticipate underreaming prior to setting casing when possible.

Gravel-Packing the Well

In well B, it was decided that the 7-in. casing would be seated at a depth of 5156 ft., 112 ft. above the total depth of 5268 ft. Beginning at 5160 ft., the hole was underreamed to bottom, a total of 108 ft. of 16-in. hole thus being obtained.

After the 7-in. casing had been set and cemented following the underreaming, 137 cu. ft. of ⅛-in. gravel was pumped-in using mud as the carrying medium. As in so many gravel-packing operations, reversed circulation was employed, pumping the mud and gravel down the casing around the tubing and obtaining the mud return through the tubing. With the screened sections of the tubing string in place, the gravel was deposited around the tubing, completely filling the hole.

The accompanying sketch of the gravel pack indicates that 90 ft. 4 in. of screen was placed opposite the producing formations only, the screen sections being separated by blank pipe.

Large Open Flows in Long Lake

The need for seriously considering the effect of abnormal differentials across the formation face in the injection wells of the Long Lake field is better understood when the potentials of wells in this area are considered.

For example, well B has a potential as a producing well of approximately 200 million cu. ft. per day and other wells in the field will gauge more than this. Inasmuch as one injection well is expected to serve several producing wells, it is apparent that such a well must be able to "take" enormous volumes of injected gas, even when the producing wells are flowing at only a small percent of their capacities. Assuming equal conditions in all wells as an example, one injection well serving ten wells producing one-tenth of their potentials would be taxed to the limit. This is on the assumption that the ability of a formation to receive gas is equal to its ability to deliver gas.

There are many factors, however, that will tend to contribute to losses of efficiency at various points in the cycle, and as each lb. of pressure lost in friction or otherwise imposes an added cost for recompression, it is imperative that these losses be reduced.

Velocity of Gas Into Sand

As an indication of the value of gaining additional exposed formation in well B by underreaming and then gravel-packing, it is of interest to calculate the increased area obtained and the approximate decrease in gas velocity through the sand face.

The circumference of a 9⅞-in. hole is 31 in. The circumference of a 16-in. hole is 50 in. By underreaming, therefore, the effective area of the exposed wall was increased by 61 percent.

The average porosity of the formations exposed in well B, based on nine samples, was 25 percent. In the 108 ft. of hole underreamed, the total pore area would be 69.7 sq. ft. and 112.6 sq. ft. in the 9⅞-in. and 16-in. holes.

Assuming 40,000,000 cu. ft. per day as a representative figure for the volume of gas being returned currently through well B, the gas velocity through the sand face would be 6.6 ft. per sec. and 4.1 ft. per sec., in the 9⅞-in. and 16-in. holes, respectively.

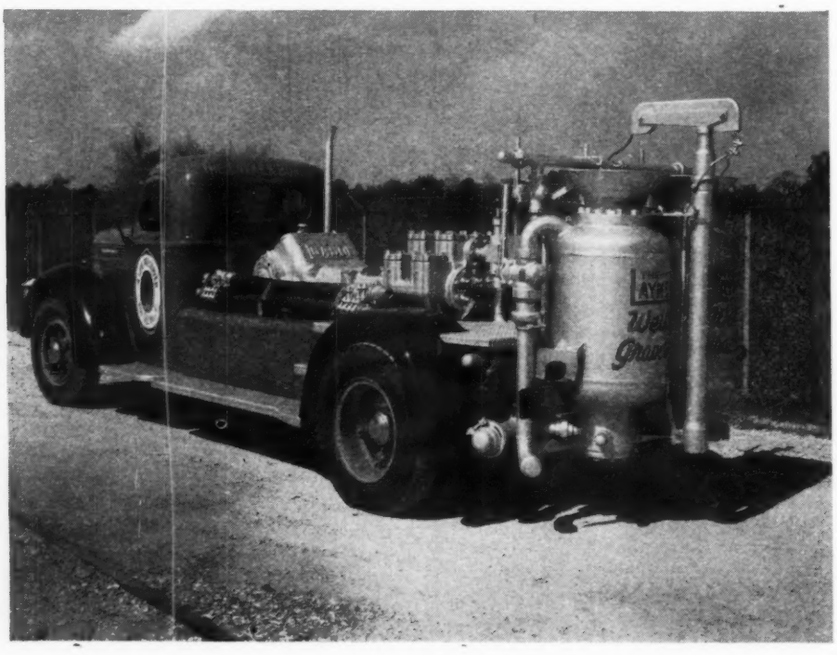
The gas velocity across the sand face is by no means the only factor determining the effectiveness of increasing hole diameter but it is an index of the rate at which gas is being injected at Long Lake with apparently satisfactory results. Not enough is known yet to be able to say whether gas velocity is a critical factor or not in gas injection, but it is definite that any added pressure required to inject gas into the formation requires additional compressor capacity and operating expense. Perhaps the velocity values obtained above could be doubled and no serious trouble would be encountered.

Gravel Prevents Clogging in Sand

An additional advantage to be derived from the presence of gravel in the well-bore of an injection well is that of protecting the formation from becoming clogged or plugged for any reason. In this respect, gravel should be as effective in preventing the flow outward into the formation of any harmful substances as it is in preventing the inflow of sand to a producing well.

Conclusion

The conditions under which the injection well at Long Lake is operating are not critical enough to permit assessment of the value of underreaming and gravel-packing thus far. The gravel-pack, however, may be considered as worthwhile insurance against contingencies that might impair the efficient operation of an injection well. Not enough is known yet about the specific requirements of injection wells in recycling projects to say what the exact conditions of operation should be.



All equipment needed in gravel-packing operation is mounted on a truck

Vapor-Liquid Phase Equilibria in Hydrocarbon Systems

Part VI.

Calculations Involved in the Design of Fractionating Columns

By GEORGE GRANGER BROWN

Professor of Chemical Engineering, University of Michigan

THE minimum pressure for the column under discussion is 190 lb. per sq. in. absolute as indicated in Table 7.

Having determined the minimum column pressure the minimum temperature in the reboiler at the base of the column when operating under a pressure of 190 lb. per sq. in. may be determined by calculating the bubble point of the product removed from the bottom of the column by equation (35):

$$\Sigma y = (\Sigma Kx) = 1$$

or

$$y_{c_3} + y_{c_4} + y_{c_5} + y_{c_{6+}} = (Kx)_{c_3} + (Kx)_{c_4} + (Kx)_{c_5} + (Kx)_{c_{6+}} = 1 \quad \ldots\ldots\ldots \quad (35)$$

The value of x for each component in the bottoms is known from Table 6, and equation (35) is solved by assuming temperatures at 190 lb. per sq. in. absolute until the sum of the values of Kx is equal to unity as indicated in Table 8.

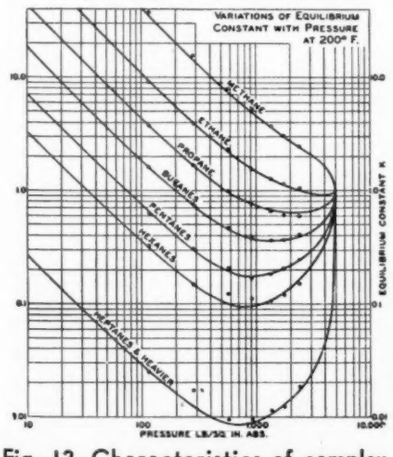


Fig. 12. Characteristics of complex mixtures (Katz and Hackmuth, *Ind. and Eng. Chem.*, 29, 1072, 1937)

If the overhead distillate is desired as a liquid product as is obtained when the column is equipped with a total condenser the minimum operating pressure may be determined by computing the bubble-point pressure of the overhead liquid distillate at 101°F. using the same composition for the distillate (Table 6) with equation (35) assuming pressures, instead of temperatures as was done for the bottom product.

In making these cut-and-try solutions it is not necessary to continue the calculations until the exact temperature or pressure is obtained, as the value of the sum of the terms in equation (34) or in equation (35) can be plotted against the assumed temperature or pressure as shown in Fig. 14. The intersection of the curve drawn through the calculated values for the sum of (y/K) or (Kx) at the assumed temperature or pressure and the line where the sum of (y/K) or (Kx) is equal to unity gives the correct temperature or pressure. The sum of the terms in equation (35) have been plotted in Fig. 14 against the assumed temperature as given in Table 8. From Fig. 14, the sum of the (Kx) terms is equal to unity when the temperature is 263°F., which is the temperature in the reboiler at the bottom of the column.

EDITOR'S NOTE: Additional charts of equilibrium constants (Figs. 13b to 13h), and Table 8, will be found in succeeding pages.

TABLE 7

Component	Mole fraction distillate gas y	205 lb. per sq. in. K at 101 °F. and 205 lb. per sq. in. absolute (Fig. 13)	205 lb. per sq. in. y/K	190 lb. per sq. in. K at 101 °F. and 190 lb. per sq. in. absolute (Fig. 13)	190 lb. per sq. in. y/K
C_2H_6	0.2180	3.0	0.0727	3.22	0.0677
C_3H_8	0.6630	0.95	0.6975	1.006	0.6585
i-C_4H_{10}	0.1093	0.422	0.2590	0.45	0.2430
n-C_4H_{10}	0.0097	0.3	0.0323	0.315	0.0308
Total	1.0000		1.0615		1.0000

GEO. GRANGER BROWN

obtained the bachelor's degree in chemical engineering from New York University in 1917—Post graduate studies, while serving as a member of the faculty in the Department of Chemical Engineering, University of Michigan, led to the doctor's degree, received in 1924—A year later, in 1925, the professional degree of chemical engineer was granted by New York University—During the period 1917-20, Brown served variously with the Aluminum Company of America, Massens, New York, the Chemical Warfare Service, Washington, D. C., and with the Youngstown Sheet and Tube Company, Evanston, Illinois—During the period 1920-24, concurrently with his studies leading to a Ph.D., Brown served with the Michigan Geological Survey as special investigator for clays, shales, and sand—He is now professor of chemical engineering in the University of Michigan and is a member of the American Institute of Chemical Engineers, the American Petroleum Institute, the Society of Automotive Engineers, the American Society for Testing Materials, the American Chemical Society, and was awarded the William H. Walker Award for 1939 for meritorious contributions to chemical engineering literature—Although his work has taken him into many branches of the chemical industry, he has always kept up active work in the petroleum industry, particularly concerning the properties of natural gasoline and its constituent hydrocarbons—This year at the Annual Meeting of the Natural Gasoline Association of America he was given the Hanlon Award for outstanding service to the natural gasoline industry.

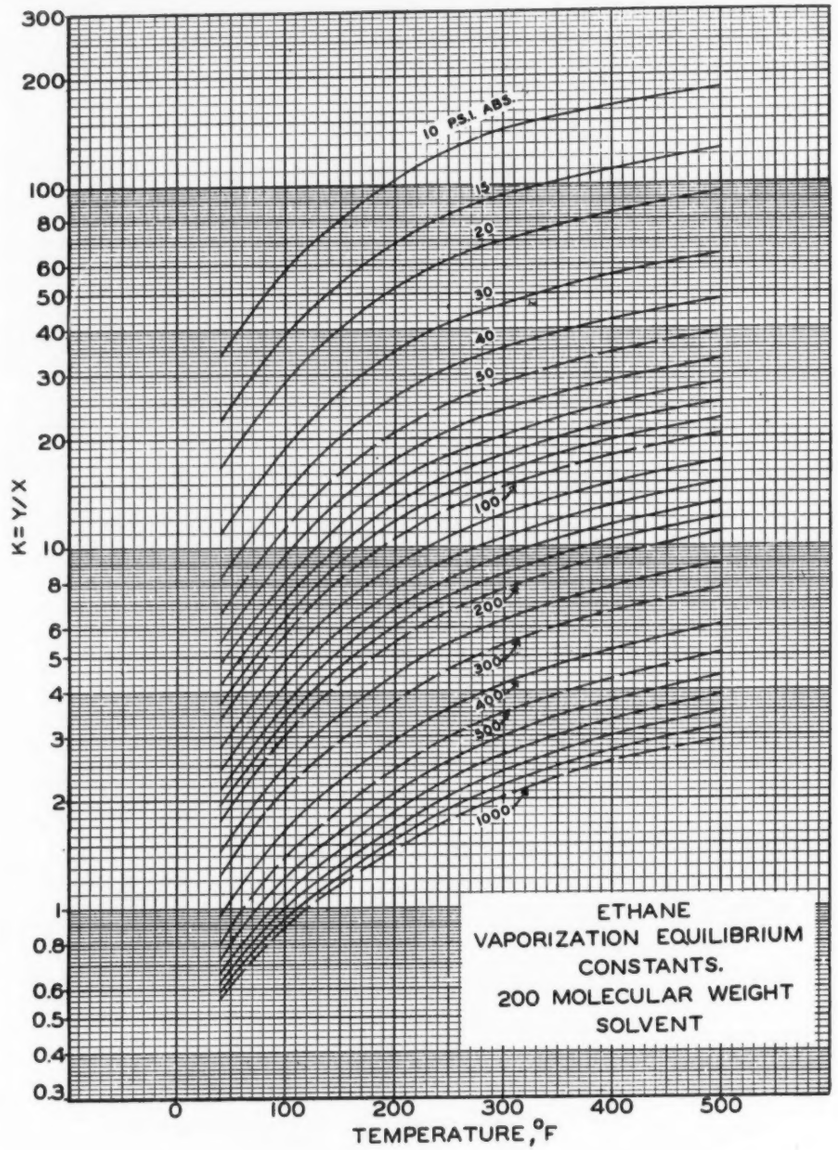


Fig. 13b. Equilibrium constants for ethane

(Copyright 1940 by George Granger Brown)

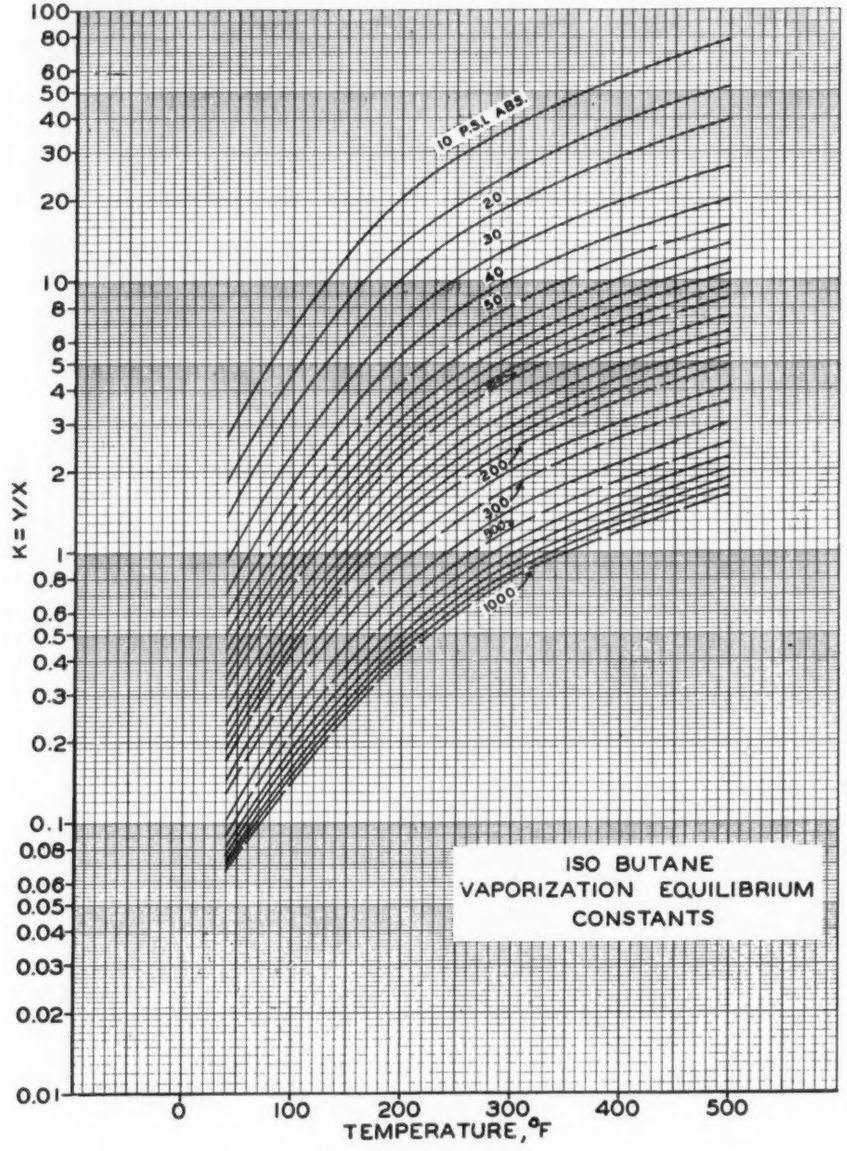


Fig. 13c. Equilibrium constants for *iso*butane

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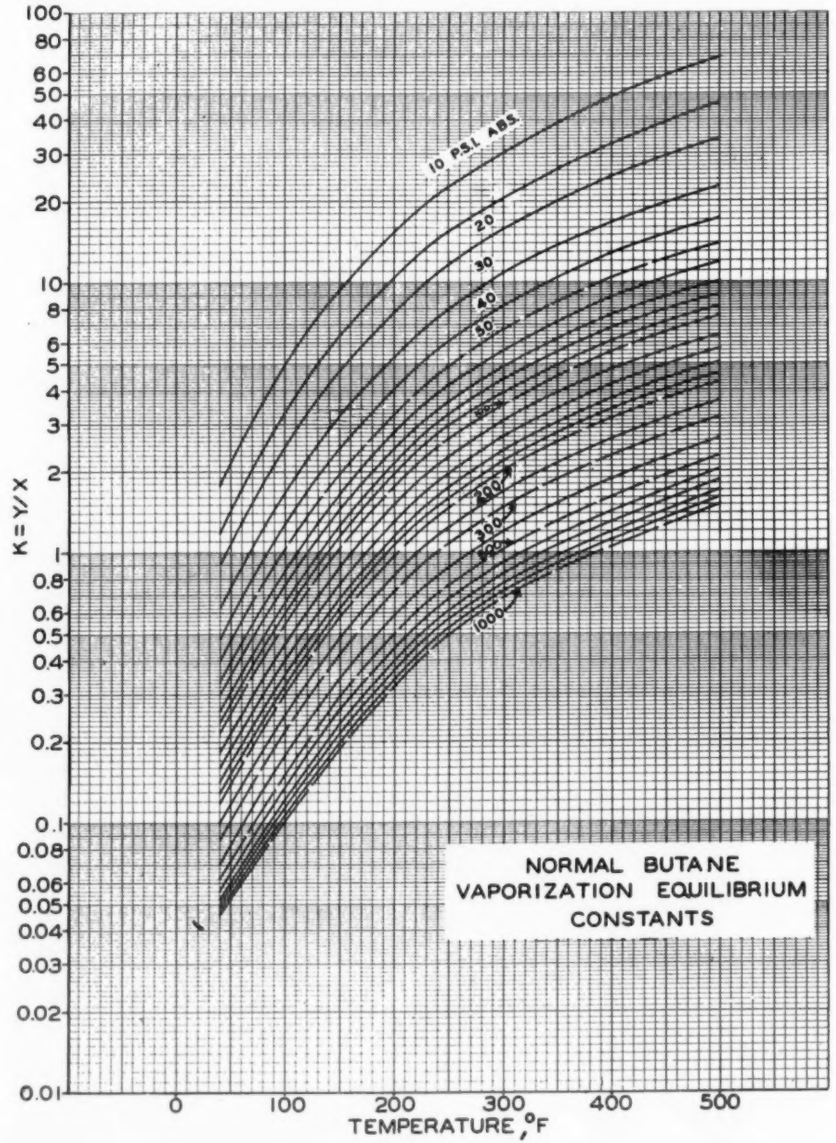

Fig. 13d. Equilibrium constants for butane

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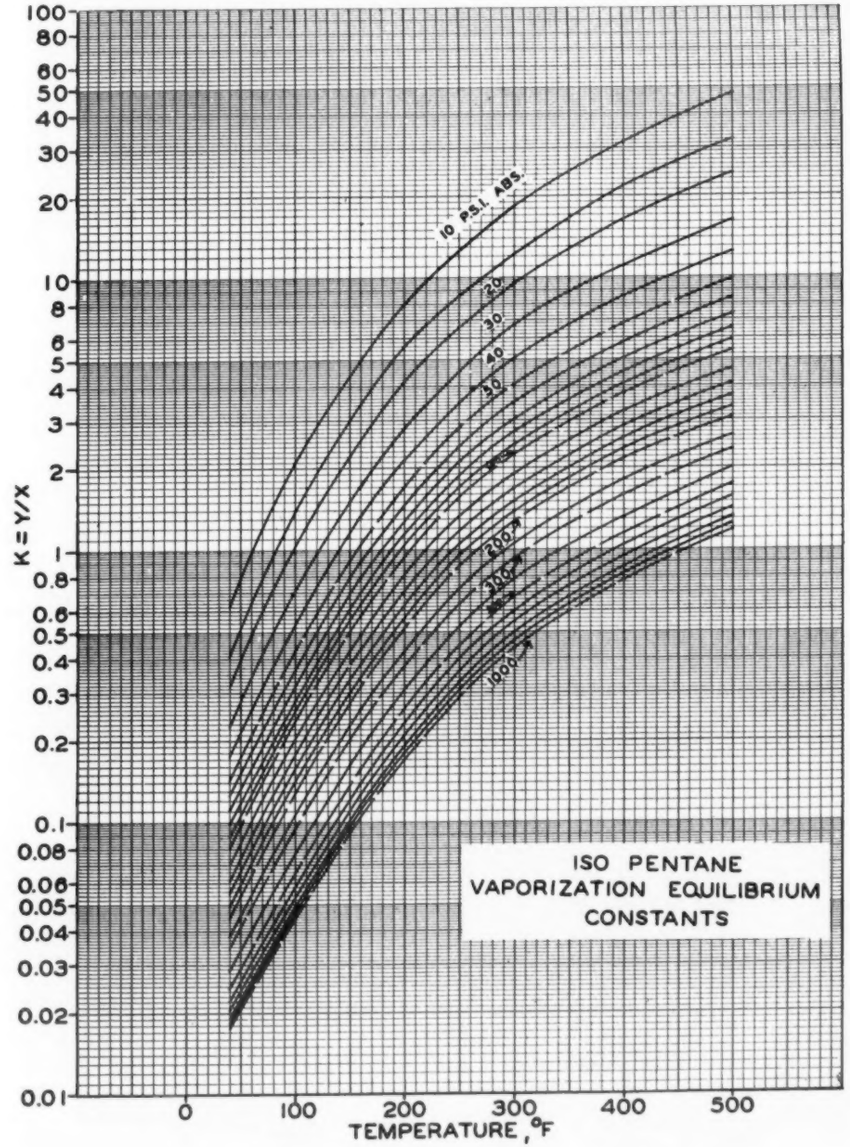

Fig. 13e. Equilibrium constants for *iso*pentane

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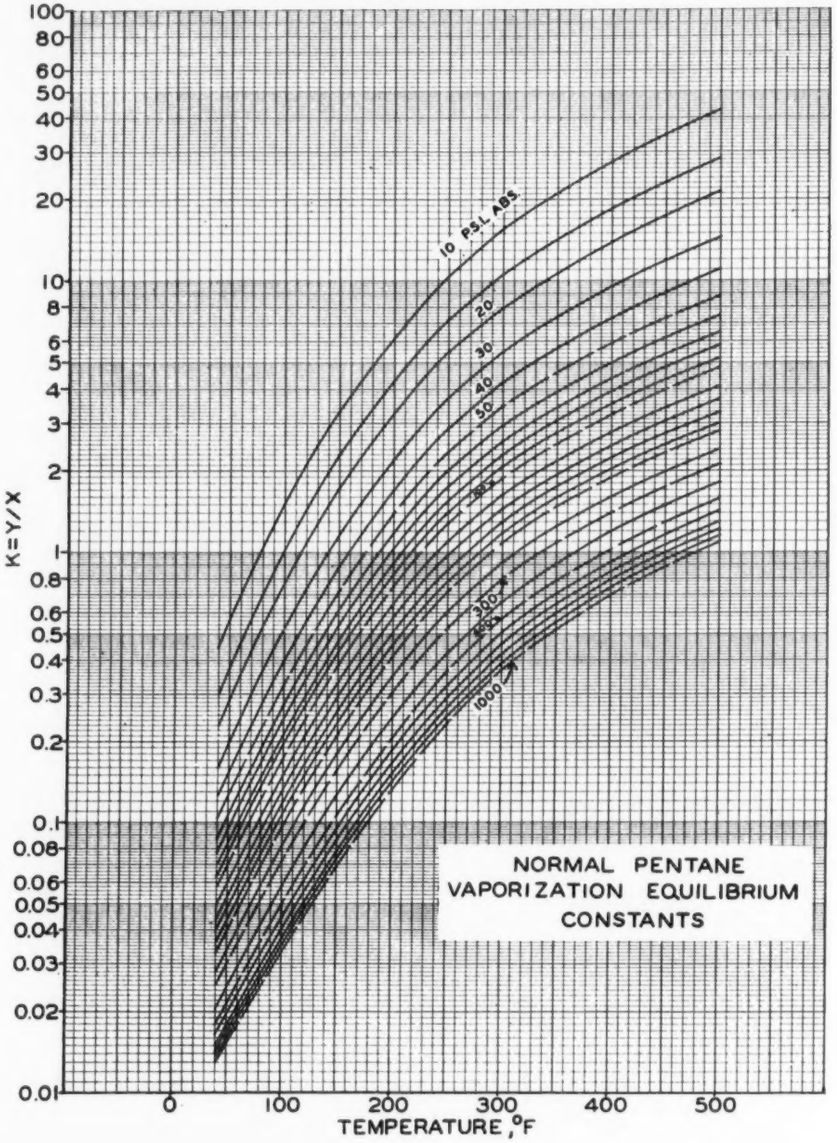

Fig. 13f. Equilibrium constants for pentane

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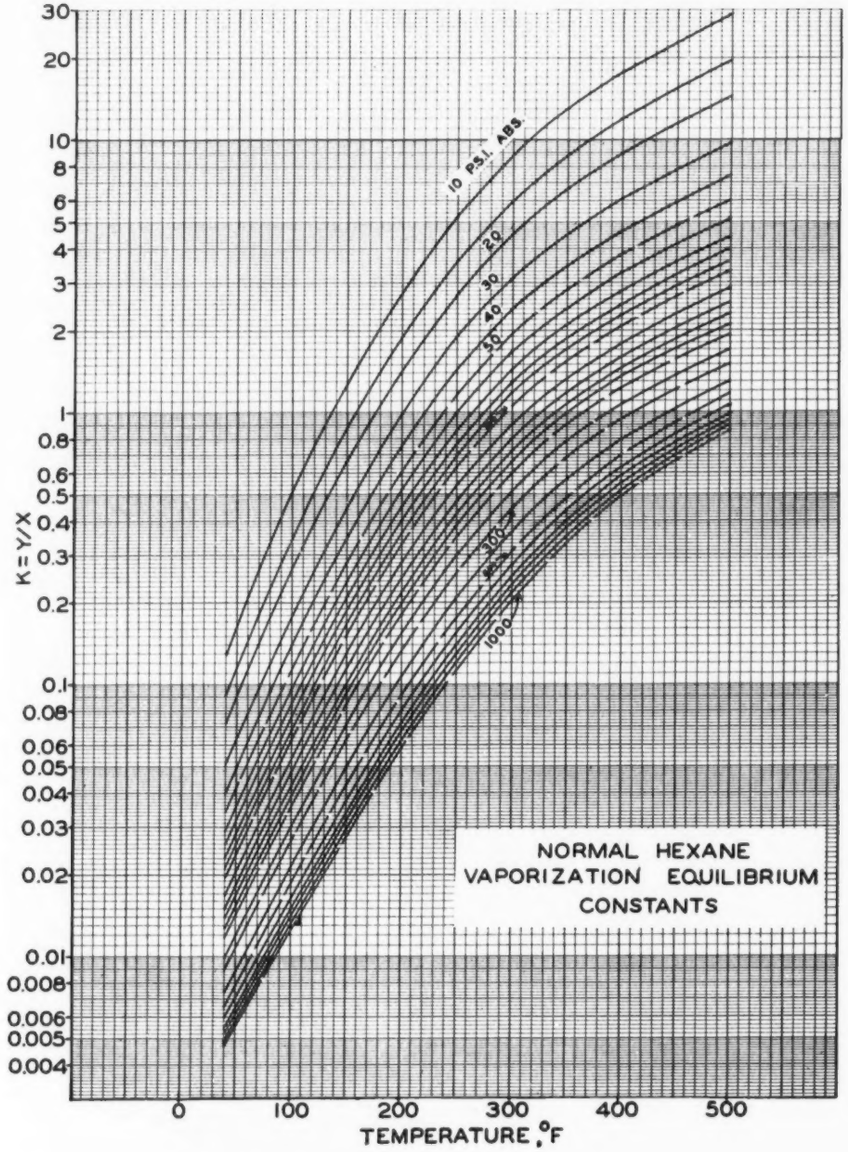

Fig. 13g. Equilibrium constants for hexane

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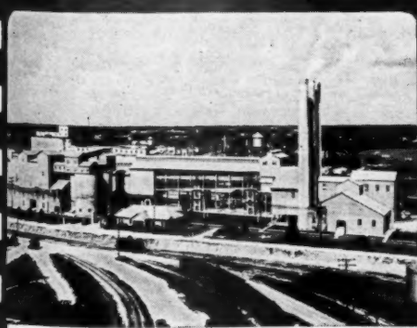

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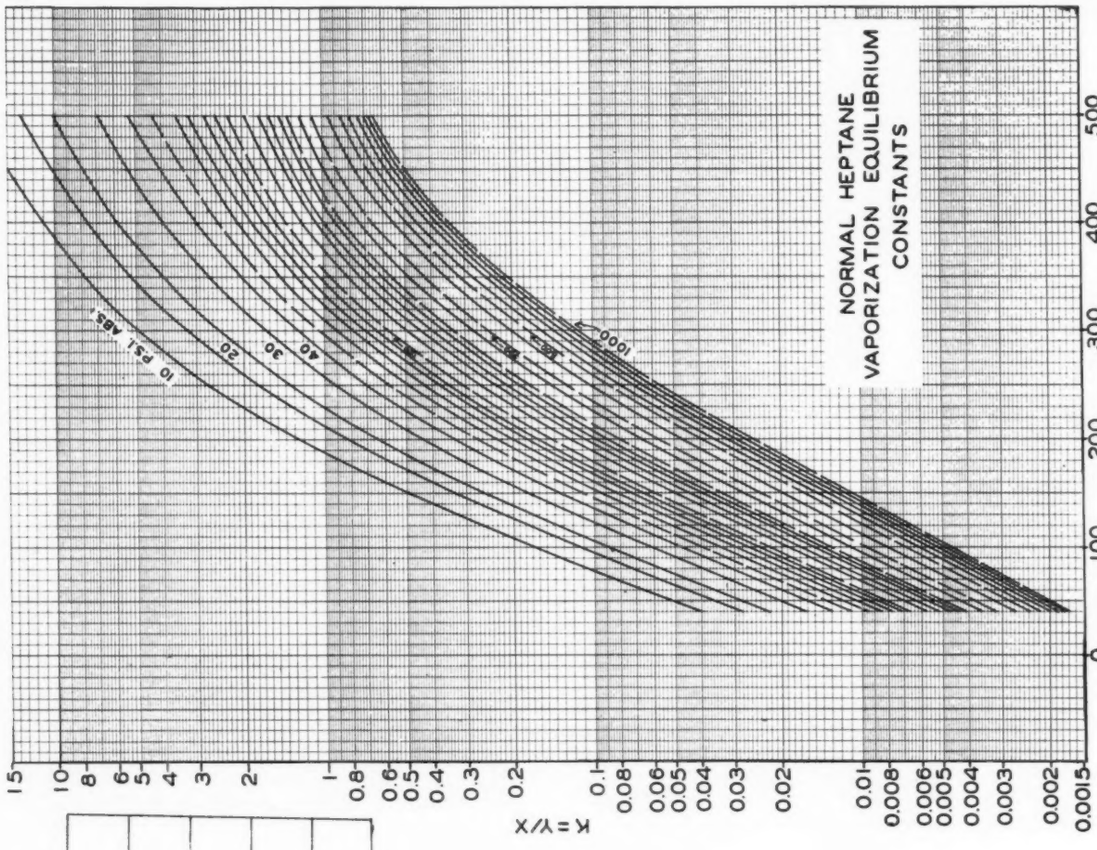

Fig. 13h. Equilibrium constants for heptane

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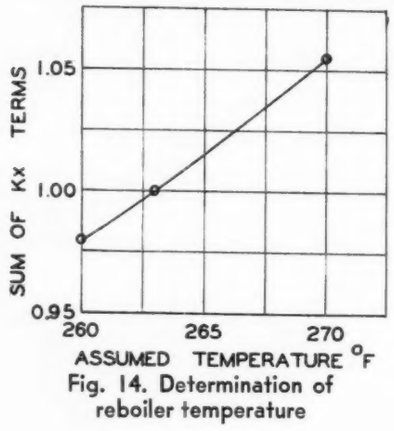


Fig. 14. Determination of reboiler temperature

TABLE 8

Component	Mole fraction bottoms x_B	K at 270 °F. and 190 lb. per sq. in. absolute (Fig. 13)	Kx	K at 260 °F. and 190 lb. per sq. in. absolute (Fig. 13)	Kx	K at 263 °F. and 190 lb. per sq. in. absolute (Fig. 13)	Kx
C_3H_8	0.0015	3.45	0.0052	3.3	0.0050	3.32	0.0050
$i\text{-}C_4H_{10}$	0.0606	2.12	0.1286	2.0	0.1212	2.05	0.1243
$n\text{-}C_4H_{10}$	0.3202	1.75	0.5605	1.64	0.5255	1.663	0.5325
C_5H_{12}	0.3277	0.89	0.2915	0.815	0.2670	0.84	0.2750
C_6H_{14} plus	0.2900	0.239	0.0694	0.208	0.0603	0.218	0.0632
Total	1.0000		1.0552		0.9790		1.0000

Fuller's Earth Consumption Continues to Decline

THE PRODUCTION of Fuller's earth or natural bleaching clays in the United States, after declining almost steadily for 9 years, showed a further drop in 1939 to 167,070 short tons valued at $1,691,855 compared with 170,852 tons worth $1,707,869 in 1938, and a peak of 335,644 tons worth $4,326,705 in 1930, according to the U. S. Bureau of Mines. Until 1930 the output of Fuller's earth increased almost directly with the rapid expansion in petroleum refining, occasional minor setbacks never lasting more than a single year, but for 1939 the F.R.B. index of petroleum refining stood at 214 compared with 200 in 1938, and only 161 in 1930. Expressed as percentages of the 1930 figures, it would seem that the domestic output of Fuller's earth had declined 51 percent whereas what was once the leading barometer of demand for bleaching clay had risen 33 percent.

Imports of Fuller's earth in recent years have amounted to only 1 or 2 percent of domestic production. According to the Bureau of Foreign and Domestic Commerce, in 1939 imports totaled 1818 short tons valued at $22,215, a small increase over the 1938 total of 1507 tons and $18,951 but less than imports in any other year since before 1900.

Exports also increased. Shipments to foreign countries are not reported separately in the Department of Commerce statistics but reports to the U. S. Bureau of Mines by producers show exports of 11,090 short tons worth $90,117 in 1939 compared with 10,046 tons valued at $81,175 in the preceding year, and 8,104 tons valued at $70,985 in 1937.

The average value per ton of the Fuller's earth produced in the United States in 1939 ($10.13) was virtually the same as in 1938 ($10.00) and 1937 ($10.15). Prices vary according to particle size. Fine material such as is used in contact refining processes is much cheaper than the carefully sized particles used in percolation processes.

Refinery Steam and Its Efficient Utilization

Thermal efficiency of superheated steam as power is analyzed—In distillation control the vapor pressure of steam rather than its temperature aids vaporization of crude oil at lower temperatures

Part 1

By R. G. LOVELL

Development Engineer, Hancock Oil Company of California

WE will set up a typical problem of selecting a steam plant for a straight-run refinery of 10,000 bbl. daily throughput capacity. The first step, obviously, is to decide what type of boiler will be best to use. And in reaching this decision we will be guided by first cost, operating efficiency, safety, and general suitability to refinery work.

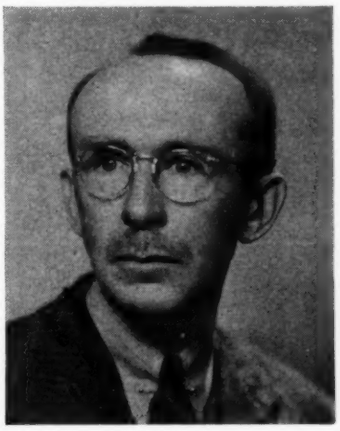
In selecting the type of boiler for a plant of the suggested capacity one can readily limit the field of choice to three: conventional bricked-up horizontal return tubular, water tube, and inside-fired horizontal return tubular.

There is not likely to be any great difference in the efficiency of any of the types mentioned if reasonable efforts are made to maintain the boiler properly. Any fire-tube boiler offers a greater potential explosion hazard and is slower in response to sudden demands for steam because there is more water under pressure than in the water-tube type. The outside-fired horizontal return tubular boiler offers an addition potential operating difficulty in that such mud and scale as is not removed in the blow-down collects in that area directly exposed to the highest furnace temperatures—the bottom of the shell. With the inside-fired type, this scale collects at the place best shielded from the high furnace temperature.

When a somewhat higher first cost is not of too much concern there can be no question of the all-around superiority for refinery use of a high-grade water-tube boiler.

In establishing the relative importance of first cost of any refinery equipment let no one fail to keep in mind that a dollar has a certain definite value per unit of time, the same as has a man or a mule. Many a man spends a lifetime complaining that his recommendations of purchase of highest grade equipment are not followed. When that man has learned the fundamental truth above expressed, and will submit with his recommendations a clear statement justifying the higher first cost of the apparatus that he is recommending in terms of time and interest rate on the money, he is likely to find that far greater weight will be given to his claims. Would an attorney go into court with the bare statement that *his* analysis showed his case to be just? He submits evidence, either oral or in the form of briefs, to support his case. If his evidence is convincing he usually wins his point.

It will be obvious that a comparison of first cost cannot be made until we know the amount and character of the duty to be required of the boiler plant. Nor can we know with any degree of accuracy the amount of steam demand until the various needs and duties of the steam have been coördinated. This is not a simple matter of adding the amounts to be used for distillation, pumping, cleaning, fire protection, etc. In point of fact, although distillation steam and that required for pumping are quite different, the amounts are, by no means, necessarily additive. A clear view of the subject of refinery steam can only be had by viewing the subject objectively so that one can get an idea of the relation of one element in the picture to the others.



R. G. LOVELL

received his academic training in New York, after which he served several years in the Engineering Department of the New York Telephone Company—Went to Bisbee, Arizona, in 1908 where he "cut his mechanical engineering teeth" in one of the first large power plants of the Southwest, that of the Copper Queen Mining Company, later the Phelps-Dodge.

He next went to Mexico where he remained until 1917 and returned to enter military service for the period of the war—Returning to Mexico after the war he served the Alvarado Mining and Milling Company of Parral as general master mechanic for two years.

Lovell left mining and went into petroleum in 1920 with the Standard Oil Company of California and since that time has been continuously associated with the oil industry, chiefly in manufacturing. His engineering career has included a wide range of practical experience with mechanical and electrical equipment in both the mining and petroleum industries—Has specialized in pumps and pumping.

For many years he has been with the Hancock Oil Company of California at Long Beach and now devotes his time largely to process and equipment development—Has also been in charge for five years of the classes in the Oil Refining Division of the Trade Extension School operated by the City of Long Beach.

Classification of Refinery Steam Duties

There are three types of duty for steam in a refinery, each of which is distinct in nature from the others. First, let's label each of these duties and then view them as a whole. In general the demands are: (1) Power; (2) Distillation, and (3) Fire extinguishing.

Power steam. The use of steam for power, either in reciprocating units, such as pumps, or to drive a turbine, involves pressure reduction and consequent loss of heat. These two factors are entirely correlative and the power to be derived from steam so used is a direct function of its temperature. This

(Copyright 1940 by George Granger Brown)

statement is strengthened by considering the advantage of using superheated steam. Superheated steam, having a temperature higher than normal steam at any given pressure, will have a proportionately higher temperature at the exhaust pressure. A greater total amount of mechanical work, therefore, can be accomplished. The increase in efficiency has been found to average 15 percent.

This gain in efficiency is due more to reduction of cylinder condensation than to any of the other factors that comprise thermal efficiency. This statement should be qualified, however, in the case of the conventional duplex direct-acting pump. The reason is clear if one gives thought to the construction of the steam end of this equipment. The inlet and exhaust valve ports are adjacent; seldom more than an inch apart. The incoming steam passes, therefore, through a port that, but a split second before, had been cooled by the exhaust. This tends, consequently, to rob some of the advantage from the superheated steam. Further, a degree of superheat that would be effective in a steam turbine, where there are virtually no problems of lubrication, would offer serious lubrication difficulties in a pump. Theoretically, there is no reason why the advantages of a mild degree of superheat as a drying agent should not be utilized if conditions are such that it is practicable.

The thermal advantage of superheated steam for turbines is too obvious to require discussion. It is well, however, to point out that much less erosion of turbine blades will occur if the steam is superheated. Also, the danger of the unbalancing effect of slugs of water striking the blades will be avoided.

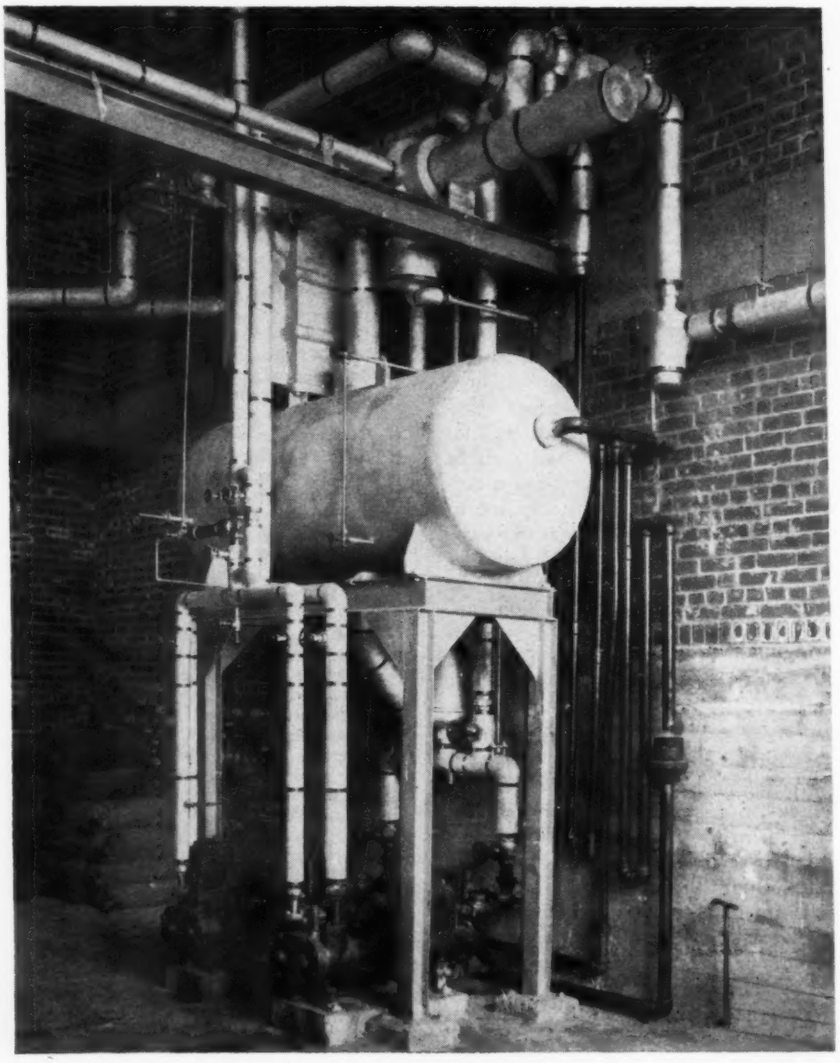
Every student of this subject who has accepted the statement that superheated steam has lower heat conductivity than saturated steam should make sure that he knows why this is true. Superheated steam is practically a true gas but normal steam should be classed as a vapor. The specific heat of a gas is substantially lower than that of a vapor. The truth of this may be amplified by the following discussion.

If a lesser amount of heat is required to raise the temperature of a unit weight of superheated steam one degree than is required for saturated steam or, conversely, if the temperature of superheated steam will be increased more by the application of a given amount of heat, then a similar rule will apply when the transfer of heat is in the opposite direction. That is, since a lesser number of heat units went into the superheated steam for a unit rise in temperature, then a reduction in temperature, brought about by an outside agency, such as cold air, or by a reduction of pressure through expansion, will cause a loss of fewer heat units. This is only a simple explanation of the greater thermal efficiency of superheated steam.

Distillation steam. It is truly surprising to realize how few operating men really know why they use steam in controlling the distillation process. The conventional reply to the question is that by using steam one can control the end point of the overhead products. The impression seems to prevail that the temperature of the steam has something to do with it. This is definitely not the case. Assume that normal steam is available at a gauge pressure of 150 lb. per sq. in. This means a temperature of 366° F. at the point where the entry to the tower or chamber is controlled. Some small amount of this heat is lost by wire-drawing through the valve, but the temperature at the discharge side of the throttling valve is close to 366° F. It can also be assumed that, in the case of a straight-run fractionating tower, the temperature of the incoming crude oil will not be far from 500° F. Obviously, steam at approximately 366° F. is not going to cause an increase in the temperature of crude oil that is already at 500° F. So we must look elsewhere for the explanation of the purpose of steam in controlling distillation.

The phenomenon of boiling is covered rather thoroughly in a previous article[1] but possibly another way of looking at the problem will aid in a clearer understanding of it. With an assumed tower pressure of 15 lb.

[1] "Practical Application of Gas Laws to Distillation and Storage Problems," by R. G. Lovell, *The Petroleum Engineer*, August, 1939.



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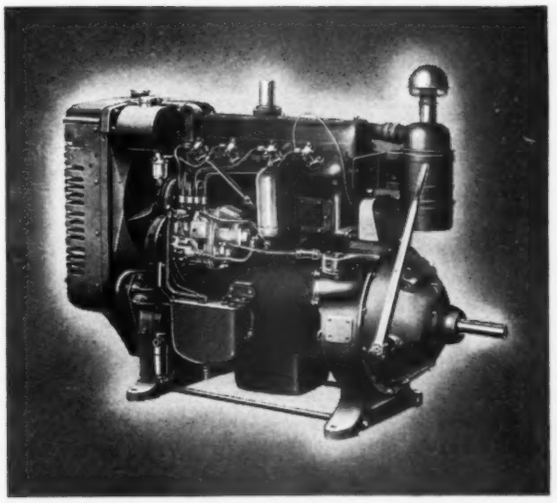

Above: **Here is International Harvester's small Diesel, the UD-6 (shown equipped for indoor use). This 4-cylinder engine packs a lot of power and is built to stand up under severe operating conditions.**

INTERNATIONAL Industrial Power

per sq. in. gauge the total (absolute) pressure would be 15 plus 14.7 or, say 30 lb. per sq. in., which must be overcome by the total vapor pressure of the crude oil stream before vaporization can take place. If the tower is 84 in. in diameter, the total absolute pressure to be equaled will be:

$84^2 \times 0.7854 \times 30 = 166{,}250$ lb.

To overcome the weight of this blanket without use of steam requires that the crude oil be at high temperature. In fact this temperature would be so high that cracking would take place and, as the pressure and time factors necessary for successful cracking are not present, the result would be an altogether unsatisfactory overhead product. When steam is present it will exert a vapor pressure of its own that will be separate and additive to the vapor pressure of the oil. The water vapor, therefore, assumes part of the job of overcoming the existing weight or pressure, with the result that the oil vaporizes at a lower temperature or, in other words, boils more violently at a given temperature. The gauge pressure and equivalent temperature have nothing whatever to do with this action. It is entirely a chemical action and is based upon the law of science which states that the vapor pressures of two or more dissimilar fluids are separate and additive. The effect of using steam in distillation is just the same as if a vacuum pump or steam jet evacuator were being used to reduce the overhead pressure. In practice, either steam or vacuum or both are frequently used, as in lube or asphalt manufacture, and for the same purpose as stated.

From the foregoing discussion concerning the use of steam for power and for distillation can easily be seen the pertinence of the following statement: Sound sense indicates that the use of the latent power released in the reduction of steam from a high to a lower pressure and the subsequent use of the lower-pressure steam for distillation is actually getting approximately double duty from the steam. Let no one think, however, that this can be accomplished without paying certain prices therefor. Just what these penalties amount to is a question of the conditions existing in a particular plant.

Gain in Generating Efficiency By Use of High Pressures

There need be no consideration given to theory in demonstrating the advantage of high-pressure steam for power work. Simple study of steam tables is sufficient if accompanied by a clear analysis of the figures.

We will select three standard pressures and analyze them as an example. The data are presented in Table 1.

For the present purpose, it will be assumed that feedwater is at 212°F. and that, therefore, there will be no factor of evaporation to consider. The total heat of the steam in the table will be representative of the work done in bringing about the conditions of temperature and pressure assumed.

TABLE 1

Pressure, lb. per sq. in.		Temperature, °F.	Heat of liquid, B.t.u.	Latent heat of evaporation, B.t.u.	Total heat of steam, B.t.u.	Specific volume, cu. ft. per lb.
gauge	absolute					
0	14.7	212	180	970	1150	26.21
150	165	366	338	857	1195	2.75
285	300	418	393	811	1204	1.55

Available Power in Steam

The relative differentials between the temperatures and pressures at admission and exhaust represent the potential ability of the steam to do power work. As the exhaust temperature cannot be lowered beyond present practice, it follows that the only available method of increasing the efficiency is by an increase of the temperature of the steam at admission. How this may be accomplished by an increase of pressure may be clearly shown; the increase of fuel consumption (as represented by the total heat of the steam) necessary to increase the pressure is negligible, so that the increase in economy, due to the higher pressure, will result directly from the rapid accompanying increase of the temperature.

The advantage of using high-pressure steam may further be indicated by considering the question from the aspect of volume. With an increase of pressure comes a decrease in volume. Thus 1 lb. of saturated steam at 165 lb. per sq. in. absolute (150 lb. gauge) occupies 2.75 cu. ft., but at 300 lb. absolute, the same weight of steam occupies only 1.55 cu. ft.

If then, in separate cylinders of the same dimensions, 1 lb. of steam at 165 lb. absolute and 1 lb. of steam at 300 lb. absolute are admitted and are allowed to expand to the full volume of each cylinder, the higher-pressure steam will expand more than the low-pressure steam, and thus will do more work. This increase in the amount of work, as was the increase in temperature, may be considered relative to the additional fuel required as indicated by the difference in the total heats of the steam at the different pressures.

In percentages the thing works out like this:

$\frac{418 - 366}{366} = 14$ percent gain in potential energy for an expenditure of ½ of 1 percent additional fuel.

The reason for this seeming "something-for-nothing" can be found in the general statement that the fuel required to impart a given amount of heat to a boiler is virtually independent of the steam pressure; the temperature of the fire is so much higher than the steam temperature that a variation in the steam temperature does not produce an appreciable effect upon the rate of heat transfer from the fire to the water in the boiler.

Another clear set of conclusions to be reached from the schedule of steam properties is that, as pressure and temperature increase, latent heat decreases and heat of the liquid increases. Translating this into simpler words: the amount of heat necessary to change a pound of water into steam is less at higher pressures but there is also more heat required to bring the water to the boiling temperature. The percentage decrease in latent heat is less than the corresponding increase in the heat of the liquid, therefore, there is a gradual, but slight, rise in the total heat required to generate steam as the pressure increases.

Steam as a Fire Combatant

There are certain clearly defined characteristics of steam that make it of value as an agent in combating fire. If they are not understood, such use of steam can easily be made that the fire hazard, in the secondary form, is definitely increased.

In a general way, refinery fires can be divided into two classes: oil burning in mass, as in a tank fire, or the flame of hot oil or vapor from a leak.

In the case of a tank fire the oil itself is not actually burning. First, the vapor from the oil—mixed with some proportion of air—has become ignited and continues to burn so long as the supply of oxygen-containing air is maintained. As the oil-air vapor continues to burn, the burned gases tend to expand, cause rupture of some part of the roof, or find exit through the gauge hatch or pressure relief valve and thus permit more vapors to burn. Each second this combustion continues adds to the heat of the liquid thereby increasing its rate of evaporation and adding to the amount of available fuel for the fire.

EDITOR'S NOTE: This article will be concluded in an early issue.

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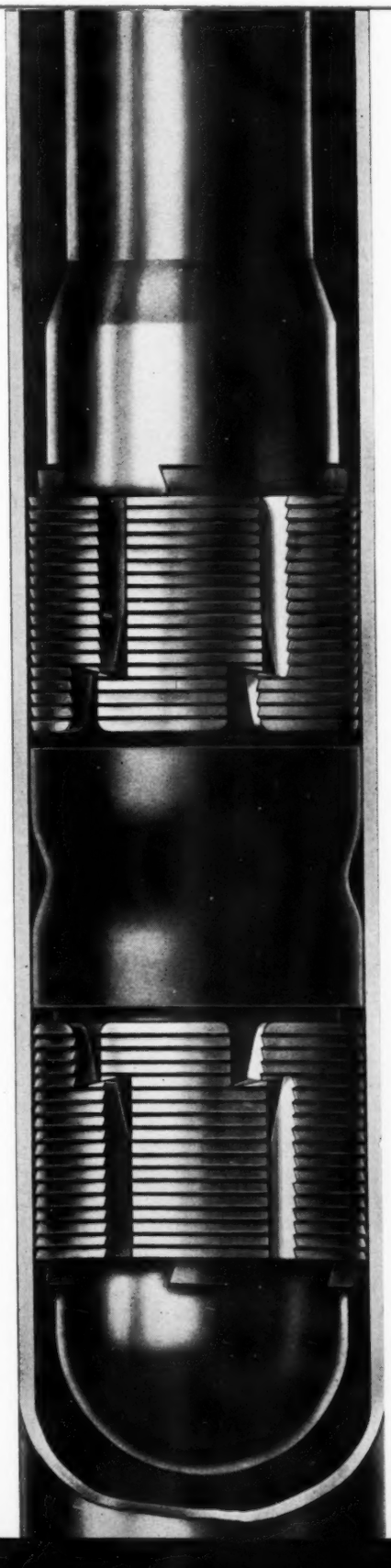

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Deepening and Completing a Well in the Lisbon Field, Louisiana—A study in Modern Coöperative Practice

Part 5

By PAUL D. TORREY, Geologist, The Sloan and Zook Company
and
FRANK H. MILLER, Petroleum Engineer
Lisbon Exploration Company, Inc.

COMPLETION (Continued)

b. Testing the Second and Third Sands. Recognizing fully the productive possibilities of the Vaughn Sand, and being somewhat dubious of the possibilities of the Second and Third Sands (owing to the low permeability indicated by the electrical survey and by core analyses), it was decided to test the lower sands before perforating opposite the Vaughn Sand. The casing opposite the Second and Third Sands was perforated according to the schedule in Table 23.

After perforating the casing the testing tool was run-in on the end of the tubing with 10 stands of water above the packer. After the packer was set the annular space between the tubing and casing was completely filled with mud, and three packer rods were dropped, the second and third rods being required because of doubt that the first rod had released the packer. The surface connections were removed and the packer pulled from the hole. The bottom-hole pressure chart indicated a bottom-hole pressure of 4800 lb. per sq. in. and a water pressure on the inside of the tubing of 435 lb. per sq. in. Incidentally, the chart indicated the first rod had successfully opened the packer. The calculated mud pressure on the basis of 10.4 lb. per gal. was 4620 lb. per sq. in. and the calculated water pressure on the packer was 420 lb. per sq. in. The check between the measured pressures and the calculated pressures was close enough for all practical purposes.

The tubing was then run back into the hole with a 5.33-ft. perforated nipple on the bottom. The bottom of the nipple was set at a depth of 8858.86 ft. The top wing arm of the Christmas tree was connected and the mud in the hole displaced by fresh water. After the mud was entirely displaced the well was washed for 2½ hr. The well was then swabbed-down to a depth of 5250 ft. with only a faint trace of gas showing, and afterwards shut-in for the night.

On the following morning the swab was run in the hole and the water level found to be at approximately the same point as on the preceding evening. There was a slight pressure on the casing and vacuum on the tubing when the valves on the Christmas tree were opened. Inasmuch as there was some question as to the effectiveness of the first perforations opposite these sands the water in the hole was displaced by mud and the hole prepared for reperforation in the same horizons. This was done in accordance with the schedule in Table 24.

Photographs and biographical sketches of the writers of this article can be found on page 155 of the February issue of *The Petroleum Engineer*, in connection with Part 1.

As soon as the last perforating gun was pulled from the hole the Christmas tree was connected to the flow line, the tubing run into the hole, and the mud in the hole displaced by fresh water. The well was then washed for 1 hr. and afterwards swabbed for 3¼ hr. The water level was lowered to a depth of 4000 ft. with only a small amount of gas showing when the well was shut-down for the night. On the following morning, when the valves on the Christmas tree were opened, there was no pressure on the tubing and only about 10-lb. pressure on the casing. The gas coming from the casing had a strong odor of gasoline. When the swab was first run the fluid level was found at approximately the same depth as on the preceding day. The well was swabbed continuously for 7 hr. and the fluid level lowered to a total depth of 7000 ft. Only a small show of rich gas appeared and it was concluded that no commercial production could be obtained from the Second and Third Sands under the conditions then existing.

The lack of production from the Second and Third Sands can be attributed to low permeability, to infiltration of mud into the sands (it being known that a filter cake formed on their faces so thick that the Schlumberger electrode was stuck during the course of making the last electrical survey), and to the closing of the pore spaces with cement at the time the 5-in. casing was cemented. It is believed that chemical treatment, using hydrochloric acid to break-down the cement around the perforations, and followed by gallic acid or quebracho to deflocculate the infiltrated mud might result in some production from these horizons. The immediate possibilities for production, however, did not look promising so further testing of these sands was discontinued.

c. Testing the Vaughn Sand. The casing opposite the Vaughn Sand was perforated in accordance with the schedule shown in Table 25. Pictures of the guns employed in perforating are shown in Fig. 10.

As soon as the last gun was pulled from the hole the tubing was run in with a 5.33-ft. perforated nipple on the bottom. The mud was then displaced by fresh water. When water began to appear in the return flow line from the casing the pumps were shut-down but the flow of water continued; at first rather slowly and then gradually increasing in volume. One hr. after the pumps were shut-down the master valve on the casing was closed and the master valve on the tubing opened and the well allowed to flow with open choke into the burning pit. Shortly thereafter the well began to make gas by heads and the flow was turned into a temporary 1000-lb.-test separator. In about half an hour after the flow had been turned through the separator light oil or distillate made

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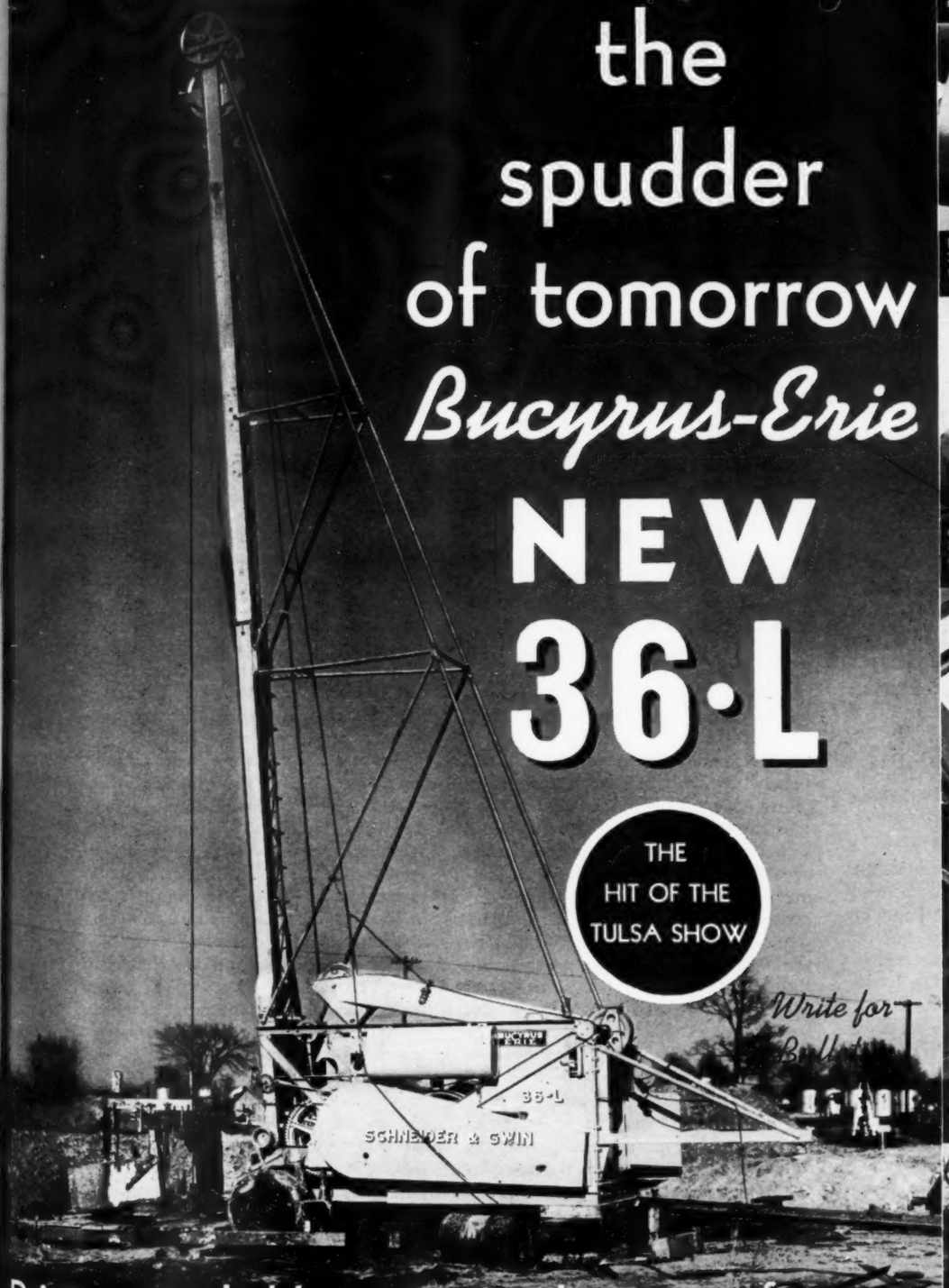

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Price remarkably attractive because of manufacturing facilities and quantity production

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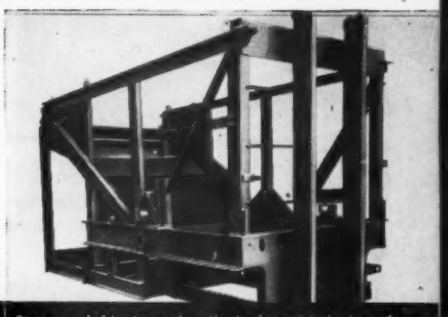
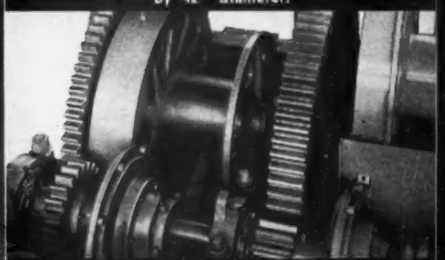
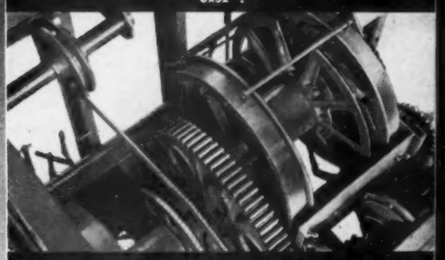


Strong, rigid, trussed, all steel, welded, box frame holds machinery in enduring alignment. Flat bottom, no projections, slides easily to platform or truck.

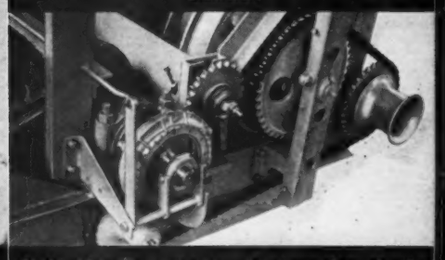
Bull reel carries up to 9,400' of ¾" line, hoists to 27,800 lbs., pulls 3,500 lbs. tools from 3,000' in 8 minutes. Big dual equalized brakes each 6" wide by 42" diameter.



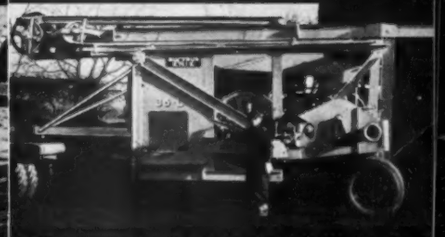
Calf reel can lift 30 tons with 6-part line, has hoisting speeds to 460 F.P.M. Center line of block automatically carried over center of hole. Brake Drum 6x32".



Sand reel will pull 7"x30' bailer from 3,000' in 3 minutes. Dual equalized brakes each 4" wide 36" diameter.



Chain drive on sand reel. All drums free wheeling with two speeds and reverse with friction clutch control.



Trailer mounted unit weighs about 23,000 lbs., hauls on highways at 40 M.P.H. or more. Two men can set up derrick in 20 minutes.

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TABLE 23

Record of first perforations opposite the Second and Third Sands

Depth	Ft.	Bullets per ft.	Total number of bullets
8809.5 to 8822.5	13	4	52
8825.5 to 8833.5	8	4	32
8845.5 to 8855.5	15	6	60
8855.5 to 8858.5	3	4	12
			156

TABLE 24

Record of second perforations opposite the Second and Third Sands

Depth	Ft.	Bullets per ft.	Total number of bullets
8812 to 8829	15	4	60
8829 to 8836	9	6	54
8851 to 8858	7	6	42
8812 to 8858	46	*	22
			178

*Approximately 1 bullet per 2 ft.

TABLE 25

Record of perforations opposite the Vaughn Sand

Depth	Ft.	Bullets per ft.	Total number of bullets
8444 to 8450	6	4	44
8450 to 8458	8	6	28
8458 to 8464	6	4	24
			96

its appearance. The pressure on the tubing at that time was 2325 lb. per sq. in. and on the separator, 700 lb. per sq. in., with the well flowing through a ¼-in. choke.

Due to freezing of the back-pressure valve between the separator and the flare, it was necessary to shut the well in and lay steam lines to the point of freezing. When temporarily shut-in, the pressure on the tubing increased to 2900 lb. per sq. in. After the back-pressure valve had been thawed-out, it was found that hydrates were forming in large quantity in the separator, so the well again was shut-in. On the following day a bottom-hole regulator was set at a depth of 5000 ft. to permit the gas to expand belowground and thus eliminate freezing the surface connections. The well was then flowed intermittently for about a week and finally almost ceased making mud and wash water. After being fairly clean of mud and water the well was closed-in, pending the arrival of productivity testing apparatus. When closed-in, the tubing pressure was 3275 lb. per sq. in. and the casing pressure was 3100 lb. per sq. in.

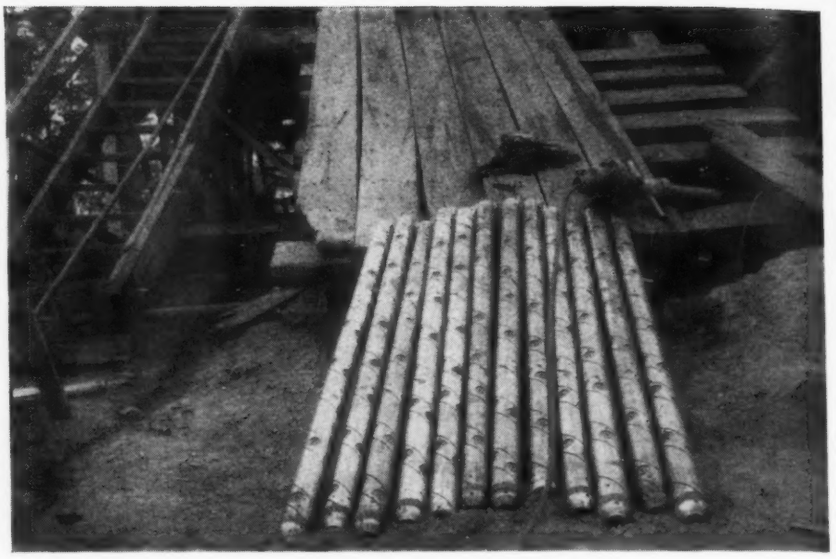


Fig. 10. Perforating guns used on the Vaughn well

4. Summary of completion procedure. A total of 40 days was employed in the completion of the Vaughn well. Much of this time was devoted to the troubles experienced in connection with the obstruction in the casing and the difficulties involved in squeezing-off the water in the First Sand. From the record that was kept of all operations it is possible to segregate the time spent on each particular job. This is given in the schedule shown in Table 26.

The time required for completions in future deep wells that may be drilled in the Lisbon field will depend largely on the conditions encountered. If no time is required for squeeze cementing or no unusual difficulties are encountered, it would seem that a well should be completed properly in a week to ten days depending on the amount of testing done. If there is any question concerning the productivity of any particular sand undoubtedly it would be the best practice to cement casing through the entire sand section and selectively gun-perforate and test each horizon separately. If 2⅞-in. drill pipe with external flush joints can be used for testing in deepening operations, and larger sizes of drill pipe used for testing in wells that may be drilled from the top of the ground, many of the difficulties experienced in the completion of the Vaughn well should be eliminated.

PRODUCTION TESTS

After the Vaughn well was reasonably free of drilling mud and wash water it was shut in for several weeks until equipment could be obtained for making production tests. The tests were made during the second week of January, 1940, by engineers of Black, Sivalls and Bryson, and this portion of the article is based upon, and in part incorporates, the report made by Frank P. Vance and Redus H. Pruitt who had charge of the work at the well. The purpose of these tests was to obtain original physical data on the recovery that could be realized from the gas under varying temperatures and separator pressures. The tests were conducted with a completely equipped portable test laboratory that is designed for the purpose of investigating the physical conditions affecting condensate and crude oil recoveries.

Pressure effects over a range of pressures from 400 to 2100 lb. per sq. in. were observed at three different temperatures, namely 65°, 80°, and 95°F. Samples for the investigation were obtained directly from the Christmas tree through a special sampling nozzle inserted in the 2-in. tubing.

The results of the tests have been graphically plotted and are shown in Figs. 11 to 22. Solid lines of the graphs are continuous over the range of experimental control. Dotted lines are used where no experimental determinations were made, but extrapolations (dotted lines) can be considered fairly accurate because of previous work and definite limiting values for this particular case.

The recovery of condensate from gas wells, such as the Vaughn well, is dependent upon adjustment of separator pressures and temperatures. At low pressures, it is a well-known fact that hydrocarbon gas-liquid mixtures tend to vaporize as the pressure is reduced. At elevated pressures, however, a reduction in pressure actually causes liquefaction and, because of this reverse action, this phenomenon is com-

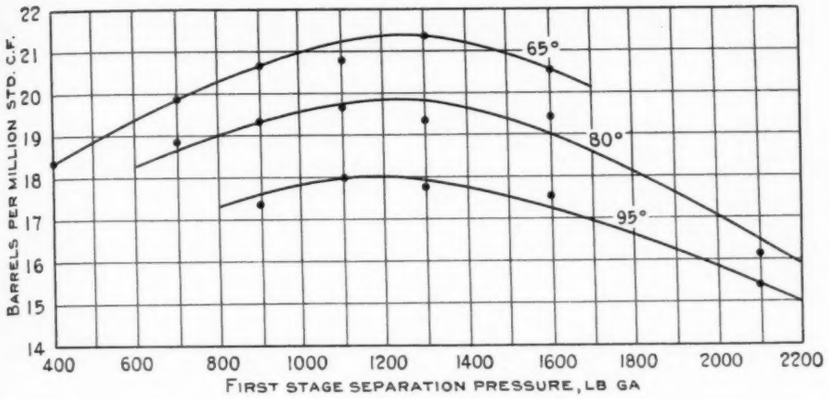


Fig. 11. Ratios of liquid and gas in well stream

monly termed "retrograde condensation" inasmuch as this condensation is contrary to normal reaction. The pressure at which this reversal occurs is determined by the composition of the reservoir fluid, and the problem is to adjust the pressure and temperature of the condensing process so that maximum volumes of condensate may be recovered.

1. Daily gas production during test. The amount of gas produced during the course of testing the Vaughn well is given in Table 27. All measurements were made with a high-pressure recording orifice meter.

2. Separated liquid characteristics. The term "accumulation" or "separated liquid" in this article refers to the volume of unstable condensate that remains as liquid at separation conditions of pressure and temperature, after separation from its associated or equilibrium vapor.

The expressions "two-stage" and "four-stage" separation are defined as follows:

Two-stage separation consists of one high-pressure separator dumping directly to atmospheric tanks.

Four-stage separation consists of a high-pressure separator dumping into two successive intermediate-pressure vessels (stage separators) and thence into atmospheric tanks.

a. Accumulation. In Fig. 11, accumulation in bbl. per million cu. ft. of separated gas at base conditions of 14.4 lb. per sq. in. abs. and 60°F., is shown plotted against pressure for three temperatures: 65°, 85°, and 95°F. The curves in Fig. 11 represent the ratio of liquid and gas in the well stream at the indicated pressures and temperatures. Three and one-half percent of the total liquid production was water. These curves do not include this volume of water. The indicated optimum point increases slightly with respect to pressure as the temperature decreases.

b. Recovery and shrinkage. Two types of vaporization constitute the limits of separation efficiency. A maximum volume of gas is evolved from condensate by "flash vaporization" as the pressure is reduced. Flash vaporization may be defined as a gas-liquid system in which the equilibrium between the two phases is constant. A minimum volume of gas is evolved from a liquid by "differential vaporization" when the pressure on the system is reduced slowly. Differential vaporization may be defined as a gas-liquid system in which the equilibrium is constantly changing. Differential vaporization, from its inherent nature, is a batch process and cannot be applied to continuous processing. A succession of flash vaporizations, however, has been found to approach differential vaporization. This method has been applied to the separation of gas from condensate, and is known as "stage separation."

The recovery curves shown on the graph in Fig. 12 indicate stable condensate at atmospheric pressure from which gas, which was in solution at separation conditions of pressure and temperature, was liberated by reducing the separator pressure directly to atmosphere (flash vaporization). Percent recovery, as indicated, is the ratio between the volume of stable condensate recovered in the stock tank and the

TABLE 26
Segregation of time consumed in completing the Vaughn well

Operation	Days
Running casing	0.7
Cementing casing and squeeze-cementing	3.2
Waiting on cement	13.0
Drilling cement plugs and retainers	4.5
Perforating	2.3
Work on construction in casing	3.2
Work on production equipment and on rig	2.3
Displacing mud and water, and testing	5.1
Swabbing	1.9
Shut-down time	3.8
Total	40.0

TABLE 27
Gas production from the Vaughn well during the production tests

Date	Volume produced, cu. ft.
1-13-40	4,810,000
1-14-40	6,600,000
1-15-40	4,260,000
Total	15,670,000

TABLE 28
Fractional analysis of a condensate sample accumulated in the first pressure stage (at 1100 lb. per sq. in. and 80°F.)

Component	Mol. percent	Liquid volume, percent
Methane	25.20	12.22
Ethane	9.46	7.01
Propane	5.74	4.65
i-Butane	1.91	1.85
n-Butane	4.26	3.98
i-Pentane	2.50	2.71
n-Pentane	3.45	3.68
Hexanes and heavier	47.48	63.90
Total	100.00	100.00

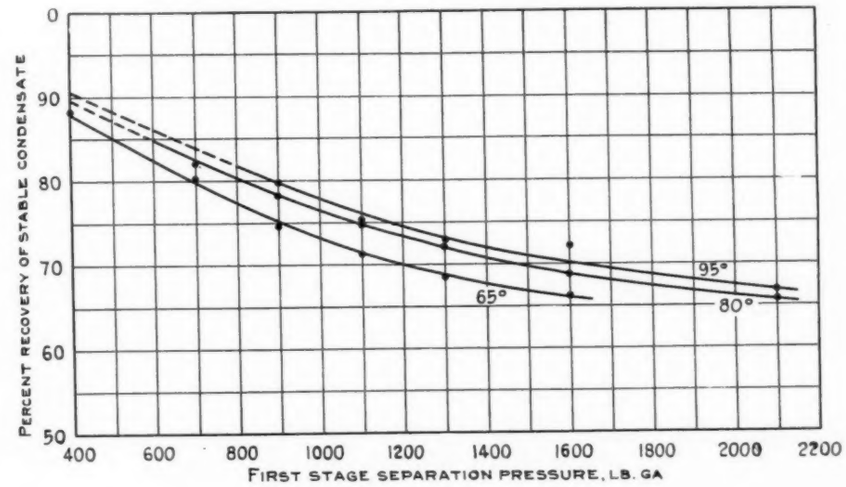


Fig. 12. Pressure vs. percent recovery

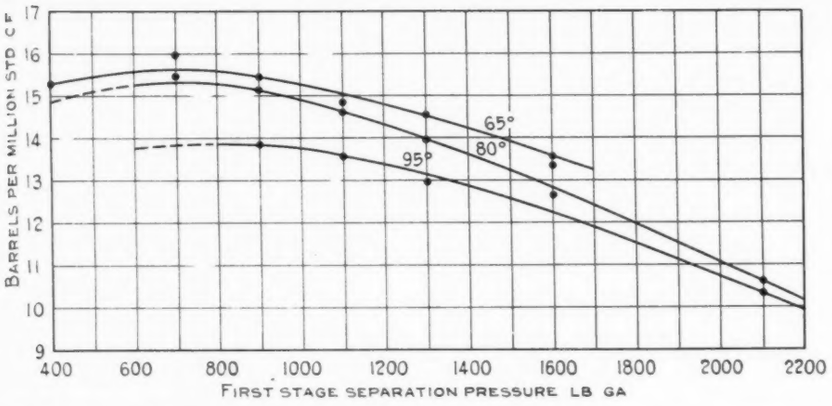


Fig. 13. Effects of pressure and temperature on condensate-gas ratios

volume of condensate accumulated at separation conditions of pressure and temperature. At separation conditions of zero lb. per sq. in., the recovery would be 100 percent. The solution gases are liberated when the pressure is reduced on the accumulated condensate, and the shrinkage (100 minus percent recovery) represents the volume occupied as liquid in the separator at the elevated pressure.

In Fig. 13 are shown the effects of separation pressure and temperature on the stable condensate-separated gas ratio. The values in these curves represent the barrels of liquid at atmospheric pressure separated from one million standard cu. ft. of gas in the separator. Compared to an ordinary lease set-up of a separator and tanks with a meter on the separator vent line, the ordinate indicates the barrels of condensate collected in the tanks for each million standard cu. ft. of gas passing the meter. The stable condensate values were determined by multiplying the accumulation (Fig. 11) by the percent recovery (Fig. 12) for the various identical separation conditions.

If a well is flowing through one separator, the optimum operating pressure for any operating temperature can be determined from Fig. 13. For a simple two-stage program of separation the optimum operating pressure for an operating temperature of 65°F. is 700 lb. per sq. in. In Fig. 14 are shown the stable condensate gravities for various separation conditions. The gravities are in degrees A.P.I. at 60°F.

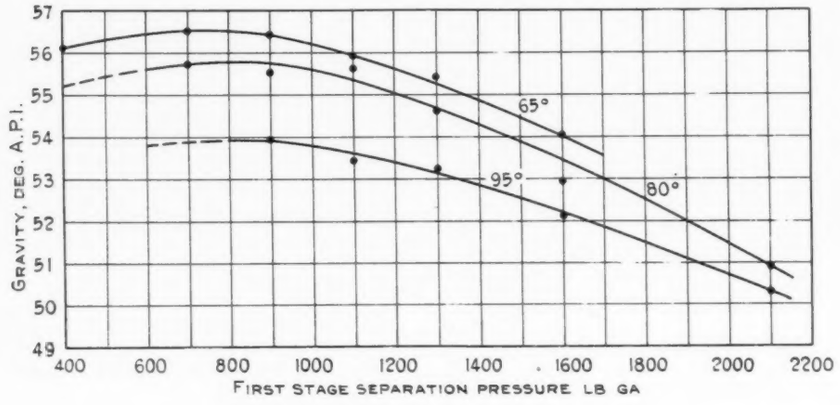


Fig. 14. A.P.I. gravity vs. pressure

c. Solubility of gas. The limits of solubility of gas in liquids can be obtained by applying the two methods of vaporization explained previously. Solubilities for differential vaporization of the solution gas are lower than those for flash vaporization. The indicated solubility for a given pressure and temperature would be identical to the volume of gas venting from a storage tank into which liquid was dumped from a separator operating at the given condition. The solubilities, as indicated in Fig. 15, represent the volume of gas in solution under atmospheric pressure per bbl. of liquid recovered at atmospheric pressure.

These solubility curves should not be confused with solubility curves as normally run on a single liquid. Every point on the solubility curves of Fig. 15 indicates the volume of gas obtained from a different condensate sample by flash vaporization, and it will be recognized that the nature of the accumulated condensate varies with separation conditions of pressure and temperature. At separation conditions of zero lb. per sq. in. the solubility would be zero.

In a following section discussing stage separation, the total solution gas separating in a four-stage system is indicated and compared to the solution gas by flash liberation.

The fractional analysis of a condensate sample accumulated in the first stage at 1100 lb. per sq. in. and 80°F. is given in Table 28.

The A.P.I. gravity of the hexanes and heavier residues is 50.5° at 60°F. The estimated molecular weight of the hexanes and heavier residue is 127.

EDITOR'S NOTE: This article will be continued in an early issue.

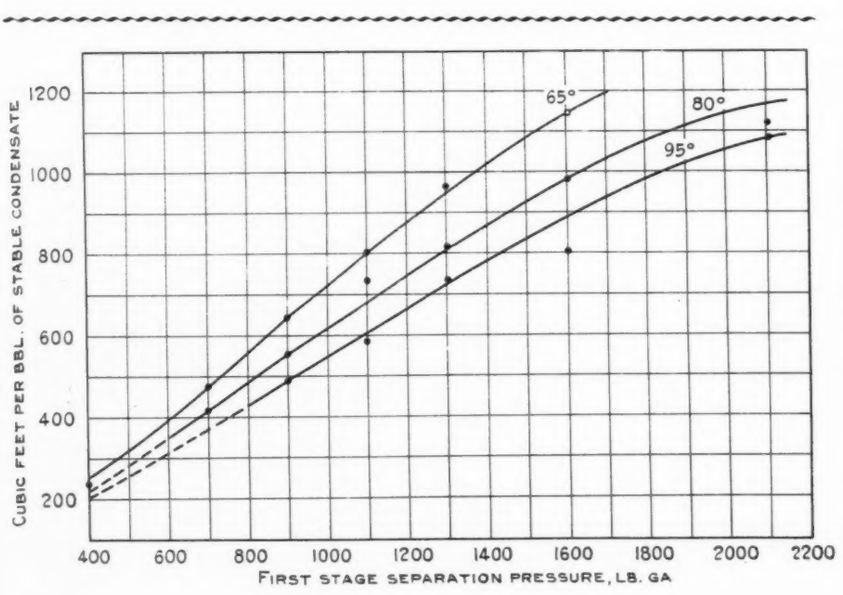
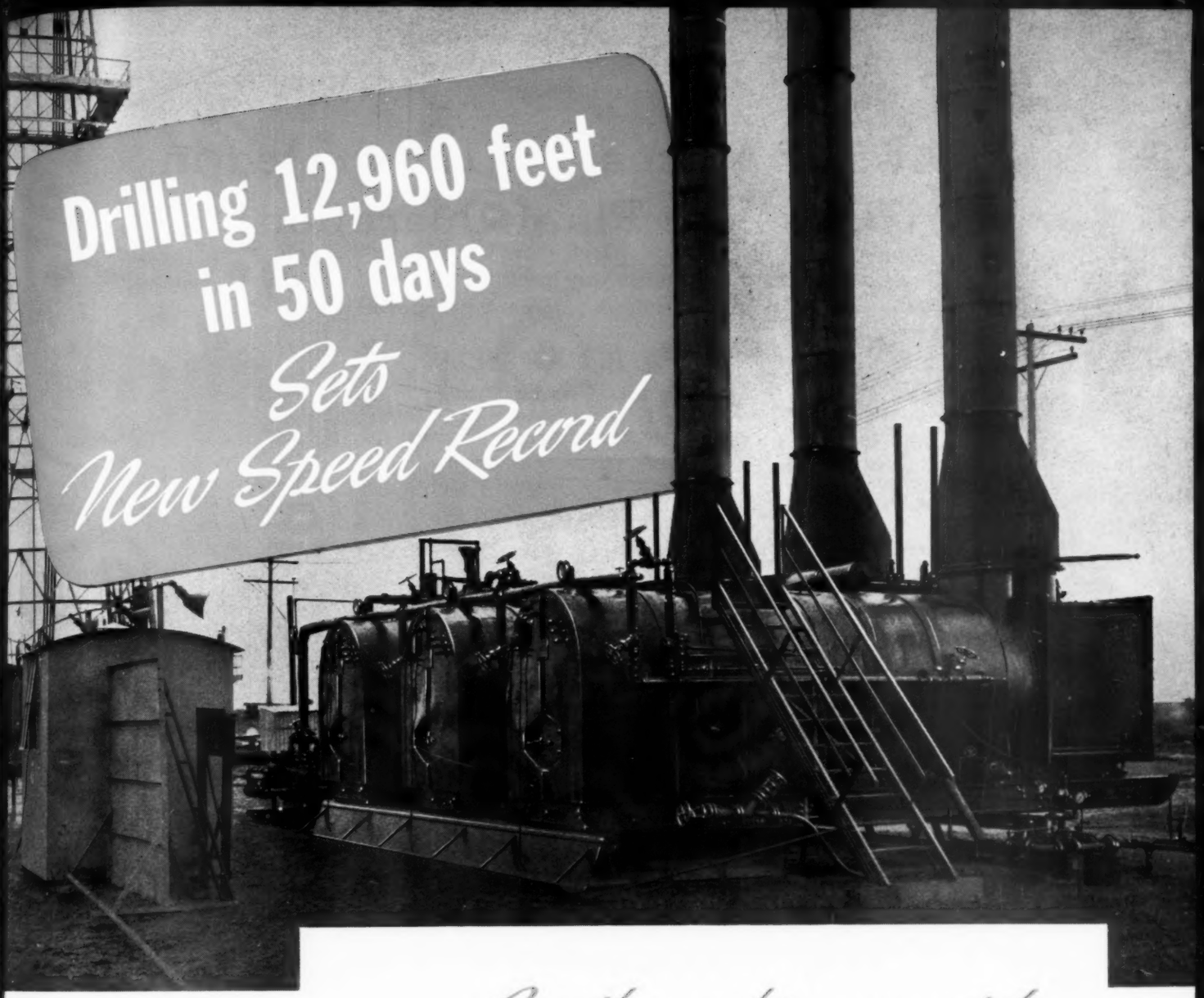


Fig. 15. Gas solubility curves



MORE POWER AT LOWER COST — that's the record of these three "Oilwell" Superheated Steam Generators that furnished all the power in making this record.

USES STEAM EFFICIENTLY— this "Oilwell" Engine-driven Power Slush Pump accounted to a large extent for the low fuel consumption.

. . . Another achievement by "OILWELL" Drilling Equipment

WHAT is believed to be a new speed record for rotary drilling has been made by Continental Oil Company in the Wasco, California, field. Drilling of this company's KCL-A5 was completed at 12,960 feet in the almost unbelievable time of 50 actual drilling days.

Ample and dependable power was furnished by three "Oilwell" No. 1 Portable Superheated Steam Generators, supplying superheated steam at 350 lbs. per sq. in. pressure. High-pressure mud circulation, which is also essential to record-breaking drilling, was provided by an "Oilwell" No. 20-P (7¾" x 20") Power Slush Pump driven by an "Oilwell" No. 9 (10" x 9") Vertical Twin-cylinder Steam Engine with variable cut-off.

This equipment *had* to be dependable and of ample capacity for such performance. That it was also efficient is shown by the low fuel-consumption record. The daily average was 609,000 cu. ft. of 1,040 B.T.U. gas. This compares with as much as 2,500,000 to 3,000,000 cu. ft. per day for some rigs in this area. On this basis, with gas at 7½¢ per 1000 cu. ft., the saving is approximately $140 per day.

OIL WELL SUPPLY COMPANY

Branch Stores in All Oil Fields
United States Steel Corporation Subsidiary

Laws of Mechanics Illustrated in Gasoline Plant Operation

The practical field man may profit by study of principles involved in the equipment he operates

By J. A. CAMPBELL
Natural Gas Engineer

WORKING as an operator of a gasoline plant, one has an unusual opportunity to study mechanics because all around him are excellent demonstrations of the fundamental principles of the subject. The moving pumps, the float controls, the steam traps, the regulators, the pressure gauges, all constitute an interesting aggregation of working models. To be a good operator one need not be a mechanical engineer but if he has a knowledge of the fundamental principles involved in the operation of the various elements of the plant, his work is more interesting and he is better equipped for his duties. In a single article it would be impossible to cover all the mechanics involved in the process of extracting gasoline from natural gas; consequently we shall only discuss here some of the more obvious applications.

Suppose we begin with pressure. In our work we deal with two kinds of pressure, static pressure and imparted pressure. The word static is derived from the Greek *statikos*, meaning to stand or weigh, so static pressure is standing pressure. The standing pressure developed by liquid depends not only on its depth but upon the density of that liquid and, of course, density means relative weight. We know that mercury is 13.55 as dense as water, which means that any given volume of mercury will weigh 13.55 times as much as the same volume of water, and a column of mercury will balance a column of water 13.55 times as high. Water weighs 62½ lb. per cu. ft. and is used as a basis for rating the densities of the other liquids. The weight of water is adopted as unity or 1; liquids that are lighter than water will have a density of less than unity, and heavier liquids will have a density greater than unity.

Suppose we have a barrel of apples. The bottom of the barrel will carry most of the weight and the static pressure, due to the weight of the apples, will be very uneven over the bottom. There will be no weight against the bottom at points were no apple is touching the bottom. Pressure will be exerted against the sides of the barrel only where the apples touch the sides. Fill the barrel with water and you have an entirely different condition. Water, being fluid, completely fills all the space and exerts a uniform pressure over the entire bottom, assuming the bottom is level. The pressure exerted on the sides is uniform for any given depth.

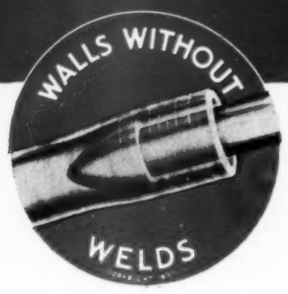
J. A. CAMPBELL

entered employ of Union Oil Company in 1917—Occupied at various times the positions of research engineer, construction engineer, superintendent of construction, design engineer, and engineer of gas plants—In 1923 accepted the position of chief engineer of the Lomita Gasoline Company, Long Beach, California, acquiring an interest in the company—In 1924 formed the J. A. Campbell Company and engaged in the design and construction of absorption plants for the next eight years—In 1932 retired from the contracting business to enter field of research and development—At the present time, he is vice-president and chief engineer of the Lomita Gasoline Company, president of J. A. Campbell Company, manufacturing and development engineers, engages in natural gas consulting work, and is an officer or director in five other companies engaged in various activities in southern California—Is a graduate of Ogden College and Yale University.

Pressure is measured in lb. per sq. in., or sometimes in lb. per sq. ft. Assume that we have a flat-sided tank 12 in. long, 12 in. wide, and 12 in. deep. This will hold 1 cu. ft. of water, which will weigh 62½ lb. The total pressure on the bottom then is 62½ lb. The unit pressure is 62½ lb. per sq. ft. Now, as the area of the bottom of this tank is 12 in. by 12 in. or 144 sq. in., to calculate the unit pressure per sq. in., divide 62.5 lb. by 144 sq. in., which gives 0.434 lb. per sq. in. In other words, on each sq. in. of the bottom of the tank are "piled up" 12 cu. in. of water, one on top of the next and the unit pressure on the bottom is 0.434 lb. per sq. in. Problem: *How many cu. in. are piled up on each sq. in. of bottom to obtain a unit pressure of 1 lb. per sq. in.?* By dividing 0.434 into 1 we get 2.304 so we know that to increase the unit pressure on the tank bottom to 1 lb. per sq. in., we must build up the sides to 2.304 times as high as 12 in. or to 27.64 in. For general calculations this is called 27½ in. and is the height of water necessary to exert a unit pressure of 1 lb. per sq. in.

Now, assume a barrel is filled with water to a depth of 55 in. This being just twice 27½ in., there will be a unit pressure of 2 lb. on every sq. in. of the bottom of the barrel. The total pressure on the bottom will depend on the size of the bottom but the unit pressure will not change unless the level in the barrel is lowered or raised from 55 in. Select a sq. in. on the side of the barrel half way up. What would the pressure be on this area? Answer, 1 lb., or half what it would be on the bottom. To determine the pressure on any sq. in. of the side, all that is necessary to know is the depth from the level of the water to the center of that sq. in. As this sq. in. is an inch wide and an inch high, the unit pressure at its lower edge will be just as much greater than the pressure at its center as the pressure at the upper edge will be less, so the pressure at the center is the average for the entire sq. in. We have already found that a depth of 12 in. created a pressure of 0.434 lb. per sq. in., so dividing by 12, a depth of 1 in. would

THESE FACTS MAY SAVE YOU THOUSANDS OF DOLLARS!



"Complete Tube Service"
21 analyses—
where and why
to use them

REFINERY operators report that tube replacement is one of the largest single items of refinery maintenance. To help you keep this expense to a minimum and to help you keep equipment "on stream" longer, NATIONAL's "Complete Tube Service" brings you 21 tried and tested analyses of steel tubes. Each has proved itself in refinery service. Each has a particular set of conditions (temperature, pressure, corrosion, oxidation, etc.) under which it is the most economical tube.

Why not put your tube replacement program on a sound engineering basis? Call in a NATIONAL Still Tube Specialist today and let him apply the experience accumulated from hundreds of refinery applications. He may be able to give you, in a few minutes, data which it would take years to assemble. He can help you select the tubes which will give you greatest service per dollar of cost.

1 **LOW CARBON**
Satisfactory at low pressure stresses to 900°F., where oxidation and corrosion are not limiting factors.

2 **LOW CARBON, ½ MOLY.**
For high pressure stresses and high creep strength to 1000°F., where oxidation and corrosion are not limiting factors.

3 **1½ SIL., ½ MOLY.**
Useful for superheater tubes and cracking furnace tubes handling non-corrosive crudes. Good creep strength and oxidation resistance to 1000°F.

4 **LOW CARBON, 1 MOLY.**
Slightly greater creep strength than Steel 2, for use to 1000°F., where oxidation and corrosion are not limiting factors.

5 **1¾ CR., ½ MOLY.**
Fair creep strength to 1150°F. Compared with plain low-carbon steel, better oxidation resistance and slightly better resistance to hot-oil corrosion.

6 **1 CR., ½ MOLY., 1¾ SIL.**
Fair creep strength and oxidation resistance to 1150°F. Steels 2 to 6 provide creep strength and oxidation resistance. Where corrosion is a limiting factor, use steels of higher chromium content.

7 **1¾ CR., ¾ MOLY. (Bain Alloy)**
Similar to Steel 5 in creep strength and oxidation resistance, but more resistant to hot-oil corrosion than low-carbon steel.

8 **2 CR., ½ MOLY.**
Good corrosion and oxidation resistance and creep strength to 1200°F. Useful in superheaters, incinerators, nitrogen fixation, and other high-temperature service.

9 **2 CR., ½ MOLY., 1¾ SIL.**
Similar to Steel 8, but better oxidation resistance. For preheater and convection tubes handling sour crudes at lower temperatures.

10 **2½ CR., ½ MOLY., ¾ SIL.**
Similar in corrosion resistance to Steel 11. Silicon content, combined with chromium, provides good oxidation resistance.

11 **2¼ CR., 1 MOLY.**
Chromium content above 2% distinctly increases corrosion resistance to sulphur-bearing crudes. Good creep strength to 1200°F., and withstands moderate to severe corrosive conditions.

12 **3 CR., ½ MOLY., 1¾ SIL.**
Similar to Steel 13. Useful to 1200°F.

13 **3 CR., 1 MOLY.**
Intermediate alloy between Steel 8 and Steel 14. Good oxidation resistance, high creep strength, useful to 1200°F.

14 **5 CR., ½ MOLY.**
Useful to 1200°F., where corrosion resistance is the principal limiting factor.

15 **5 CR., ½ MOLY., 1½ SIL.**
Useful for severe corrosion. Good oxidation resistance to 1500°F. fair creep strength and good corrosion resistance to 1300°F.

16 **5 CR., ½ MOLY., Ti.**
Similar to Steel 14, but with titanium to stabilize the alloy. This restricts air-hardening in welding and hot forming operations. Develops a dense, tight scale which restricts oxidation losses.

17 **5 CR., ½ MOLY., Cb.**
Similar to Steel 16, but stabilized with columbium.

18 **18-8 STAINLESS**
Useful for highly corrosive materials and extremely high pressures. High creep strength and excellent resistance to corrosion and oxidation to 1500°F.

19 **18-8, TITANIUM**
Similar to Steel 18. Titanium stabilizes the alloy, protects it from sensitization, making it adaptable for welding.

20 **18-8, COLUMBIUM**
Similar to Steel 19, but stabilized with columbium.

21 **25 CR., 20 NI.**
Useful where extreme resistance to oxidation is required, in polymerization, hydrogenation, hydro-cracking, and other high-pressure processes. Good creep strength and corrosion resistance to 2000° F., with little scaling. Caution: do not use at high temperature in contact with oxidizing high-sulphur gases, due to resulting corrosion embrittlement.

NATIONAL TUBE COMPANY

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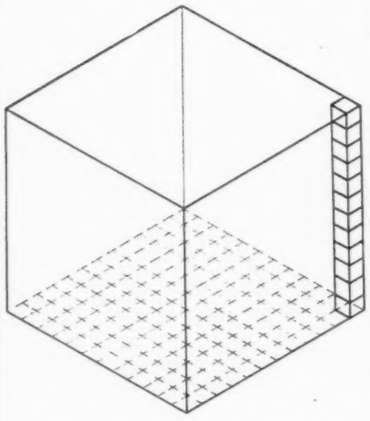
UNITED STATES STEEL



In a 1 cu. ft. box, each of the 144 sq. in. of bottom surface is loaded equally by the weight of 12 cu. in. of material above it.

create a pressure of 0.03617 lb. per sq. in. If we wish to know the unit pressure exerted at a point 17 in. below the surface, we multiply 0.03617 by 17 and obtain 0.6149. In other words, a head of 17 in. of water will exert a unit pressure of 0.6149 lb. per sq. in.

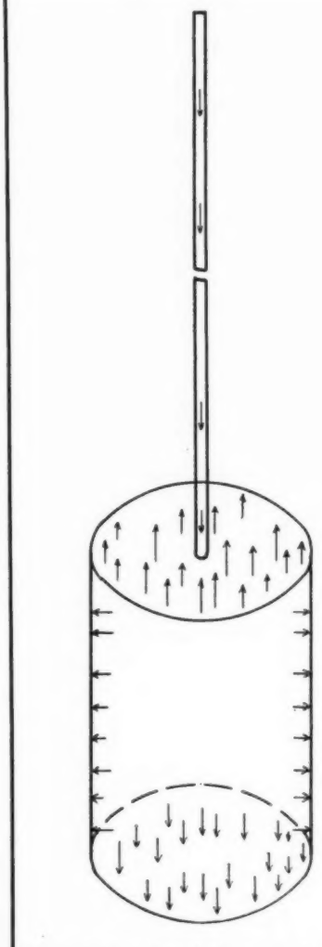
As a practical problem what would be the shut-in pressure, as shown on a pressure gauge, on a water line in a plant if that line came from a tank on top of a hill 130 ft. above the plant when the tank had 9 ft. of water in it? The water level will be 139 ft., which equals 1668 in. Multiplying 1668 in. by 0.03617 lb. per sq. in., we get as an answer, 60.33 lb. This, of course, is the static or standing pressure on the line at the gauge. If water is flowing through the line the gauge will record less because of the line friction, which will depend upon the size of the line and the amount of flow.

Let us assume that we have a cylindrical tank, the heads of which have an inside diameter of such dimensions that the area is exactly 1 sq. ft. If the tank is 2 ft. high, it will hold 2 cu. ft. of water. Set the tank on the scales and determine its total weight empty. Now drill a hole in the top and erect a tube 50 ft. high and ¼ in. in diameter. Determine the combined weight of tank and tube. Next completely fill the tank and the tube with water. We know that the water necessary to fill the tank weighs 125 lb. and we calculate the weight of water necessary to fill the small tube and find it to be 1.0655 lb. It is evident that by filling the tube with water we have increased the weight on the scales by only 1.0655 lb. after the tank had been completely filled. We have increased the unit pressure on the bottom head, however, by 3125 lb. because we have increased the static head by 50 ft. and a 50-ft. static head is exerted on every sq. in. of the bottom head. This looks like a poser. How can we increase the pressure upon the bottom head by 3125 lb. when it is resting directly on the platform of the scales and yet record an increase of only 1.0655 lb. on the scales? This will require some explaining.

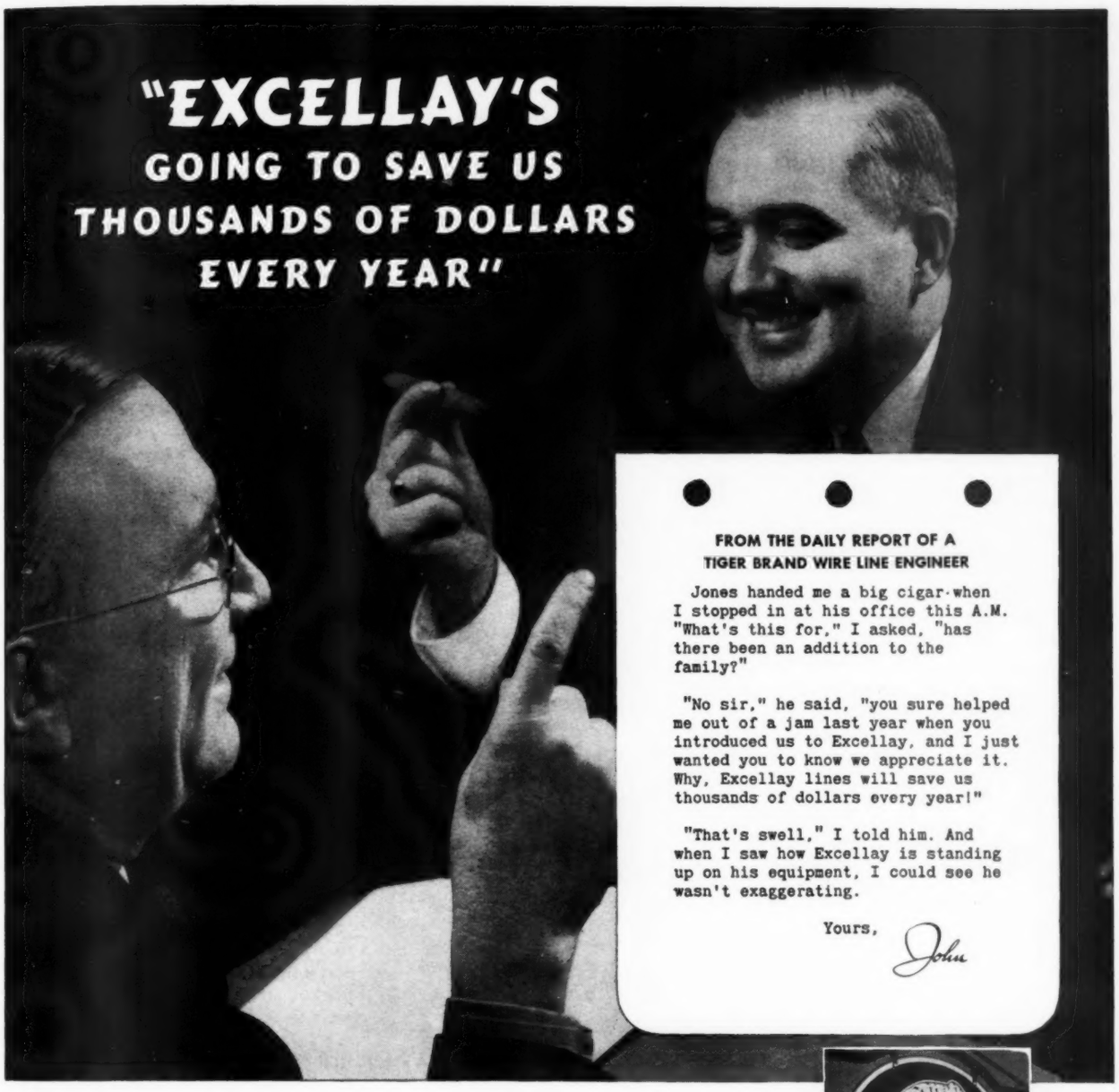
One of the first laws of mechanics is that when a body is at rest, all the forces acting on it are in equilibrium. When a body is in motion the forces acting in the direction of that motion are greater than the forces acting in the opposite direction. The force of gravity acts in a vertical direction downward on all objects. When a tank is resting on a foundation, the foundation is "pushing" up on the tank just as hard as the tank is bearing down on the foundation and the ground beneath the foundation is "pushing" up with a total force just as great as the combined weight of the tank and the foundation. Now if through the softening effect of water the ground is weakened so that its upward push is not great enough to oppose the combined weight of the foundation and tank, we will have unbalanced forces and the foundation will settle until the ground is sufficiently compacted to offer the required resistance.

Getting back to our example, we have increased the downward force on the bottom of the tank by 3125 lb., yet the downward force on the scales was increased only 1.0655 lb. Yet the scales are in balance, showing the forces are in equilibrium so we must have in some way applied an upward force on the tank bottom of 3123.9345 lb. How could we have done this? Water pressure at a given depth is uniform in all directions and the 50-ft. static head above the top head is exerting an upward force on every sq. in. of the area of the bottom side of that head. Its total area is 1 sq. ft. less the area of the ¼-in. tube, which is only 0.0491 in. We have learned that 1 ft. of water head exerts a pressure of 0.434 lb. per sq. in. so a 50-ft. head would exert a pressure 50 times as great or 21.7 lb. per sq. in. Then the total force on the upper head would be 21.7 times 143.9509 or 3123.73 lb. This is a close check on 3123.93 and would have come out much closer had we carried our decimals further. We see from this that the upward force of the static head on the top of the tank exerted an upward pressure that was transmitted as a strain through the shell composing the side of the tank, thus exerting a lift on the bottom applied equally all around the edge. There was no area to act on where the hole through the tube was so the only increase on the scales was the effect of the additional height of a 50-ft. static head on an area of the bottom head equal to the area of the small tube and this figures out to 1.0655 lb.

But what has all this to do with mechanics in a gasoline plant? Take the shipping pump for instance. We may be bucking a line pressure of 600 lb. per sq. in. yet we may have a steam pressure on the boilers of only 150 lb. per sq. in. When we have motion, the force in the direction of motion must be greater than the opposing force. Can we buck 600 lb. with 150 lb.? Yes, because these forces are not total forces but unit forces. If the fluid-end piston is 4 in. in diameter, it will have an area of πr^2. If the diameter is 4 in., r, the radius, is 2 in. and 2 squared times 3.1416, which is π, equals



Illustrating the balance of forces when unit pressure may be increased materially by only slight increase in weight of liquid.


"EXCELLAY'S
GOING TO SAVE US
THOUSANDS OF DOLLARS
EVERY YEAR"
FROM THE DAILY REPORT OF A
TIGER BRAND WIRE LINE ENGINEER
Jones handed me a big cigar when I stopped in at his office this A.M. "What's this for," I asked, "has there been an addition to the family?"
"No sir," he said, "you sure helped me out of a jam last year when you introduced us to Excellay, and I just wanted you to know we appreciate it. Why, Excellay lines will save us thousands of dollars every year!"
"That's swell," I told him. And when I saw how Excellay is standing up on his equipment, I could see he wasn't exaggerating.
Yours,
John

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12.5664 sq. in. and the total opposing force offered by the line pressure of 600 lb. per sq. in. acting on 12.5664 sq. in. equals 7539.84 lb. The total force on the steam piston to produce motion in the right direction must be greater than this amount. If the steam pressure is 150 lb. per sq. in., dividing 7539.84 by 150, we get 50.26 sq. in. as a balancing area. This area should be about 20 percent greater to allow for friction and inertia and assure a sufficient unbalancing of total forces to permit the running of the pump at its rated capacity. We should have then about 60 sq. in. in the steam piston area. As this equals πr^2, dividing 60 by π or 3.1416, we get approximately 20, and the square root of 20 is very nearly $4\frac{1}{2}$ so the diameter of the steam end would be 9 in.

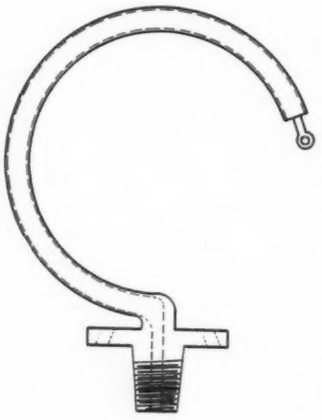
There is a much quicker and simpler way of figuring this. As the unit pressure on the fluid end is four times as great as the unit steam pressure the area on which the steam pressure acts must be more than four times as great as the area on which the fluid pressure acts. As the areas of circles compare as the squares of their diameters, the steam piston must be more than twice the diameter of the fluid piston. Pumps do not come in all sizes so we must select a size such that the ratio of steam-piston diameter to fluid-piston diameter when squared is at least 20 percent greater than the ratio of line pressure to steam pressure. Stating our selected example mathematically: $(9/4)^2 > 120$ percent of $600/150$. Simplifying: $81/16$ must be greater than 120 percent of 4, which is 4.8. Dividing 81 by 16 we obtain $5.06 > 4.8$, which is true.

Looking in the catalog we select a 10 by 4 by 12 pump, which is the conventional way of saying that the steam cylinder is 10 in. in diameter, the fluid end 4 in. in diameter, and the stroke 12 in., and we know we are safe. This pump will have a definite capacity at a recommended maximum operating speed. If this is not large enough for our purposes we will select a larger pump, keeping the ratio between the two cylinders the same as nearly as possible.

Suppose, however, that we wish to use the exhaust steam from the pump for agitation or some other processing at 50-lb. back pressure. This reduces the effective pressure on the steam end to 100 lb. per sq. in. and we shall have to figure the pump size again.

What happens when we close down on the throttle valve of a steam pump? We know the pump slows down but why? We are reducing the pressure in the cylinders. No matter how nearly closed the throttle valve is, so long as it is open at all, full line pressure will in time build-up against the piston if we, by some outside means, prevent the piston from moving. So long as the piston is moving, however, more steam must squeeze through the throttle valve to maintain the pressure, which keeps it moving. The greater the extent to which the throttle valve is closed, the greater the time required to build-up this force and the slower the movement will be.

The most common instrument for measuring unit pressure is the pressure gauge. This consists of a Bourdon tube that is decidedly curved. The tube is made of tempered copper or some special alloy and is flattened in cross-section. One end is closed and the pressure is admitted to the other end. This end is fixed and the closed end is free



Bourdon tube used in pressure gauges

to move and is connected by means of gearing (usually a form of rack and pinion), to the hand so as to rotate it clockwise with increasing pressure. Pressure tends to flatten the tube and the free end moves, thus imparting motion to the hand. Why does pressure tend to straighten the tube? We are back to our law of unbalanced forces. The tube, being tempered, is in the nature of a spring. Being curved, the area in the inside of the curve is less than that on the outside. The unit pressure for any given value, of say 50 lb., is the same everywhere inside the tube, but the total pressure on the curved wall of larger radius is greater than the total pressure on the curved wall of smaller radius. This unbalanced struggle between unequal forces produces movement until some other force comes to the aid of the weaker side. This other force is the spring resistance of the tube and it gets stronger and stronger as the tube straightens and its strength increases proportionately to the degree of straightening of the tube. So, if we increase the pressure to 70 lb. per sq. in., enough strain is induced in the spring tube to offset the increase in pressure but only after the tube has straightened to some extent. No further movement of the tube, and consequently of the hand, will occur until the pressure is changed. Should the pressure be reduced the 70-lb. strain built-up in the spring will overcome the decreased pressure and restore the greater curvature of the tube. The straightening effect and the recovery are proportional to the changes in pressure so long as the pressure is not great enough to exceed the elastic limit of the spring, which is the point beyond which it will take a permanent set. A dial back of the hand properly calibrated will record the unit pressure within the tube in lb. per sq. in. Care must be taken not to subject the tube to temperatures sufficiently high to destroy its temper. That is why "pigtails" are used on pressure gauges on boilers and lines and vessels containing hot vapors or liquids. The trap in the loop accumulates condensate or permits the hot liquid to cool and this protects the temper of the tube.

We see now that total pressure is the product of unit pressure and the area on which it acts. We readily see why it is so much easier to "stab" a $\frac{1}{4}$-in. nipple into a connection against a 30 lb. per sq. in. pressure than it is to "stab" a 2-in. nipple. If we wish to plug a 2-in. opening against pressure we usually put a valve on a nipple and open the valve. The force we are bucking then is only the unit pressure multiplied by the net annular area of the end of the pipe plus the flow reistance through the nipple. If we tried to do this with the valve closed, we would be opposing a force equal to the unit pressure multiplied by an area equal to π times the square of the outside radius of the pipe.

The total pressure acting on the top head of a high-pressure absorber is tremendous and often requires bolts of special alloys heat-treated to give the required safety factor. Take for example a 4-ft. diameter absorber operating at 500 lb. per sq. in. pressure. The cross-sectional area of the top head is πr^2 or $3.1416 \times 576 = 1809.56$ sq. in. At 500 lb. per sq. in., this means that the bolts must take a strain amounting to 904,780 lb. or more than 450 tons.

The operator who is interested in his work will find many opportunities for using these simple fundamentals and by so doing will make his work increasingly interesting and enjoyable.

P 511.222

Multiple Production From Several Zones Controlled by Bottom-Hole Chokes

EXCLUSIVE PETROLEUM ENGINEER FEATURE

Gas from one formation used to flow oil from other formations in Montebello field, California

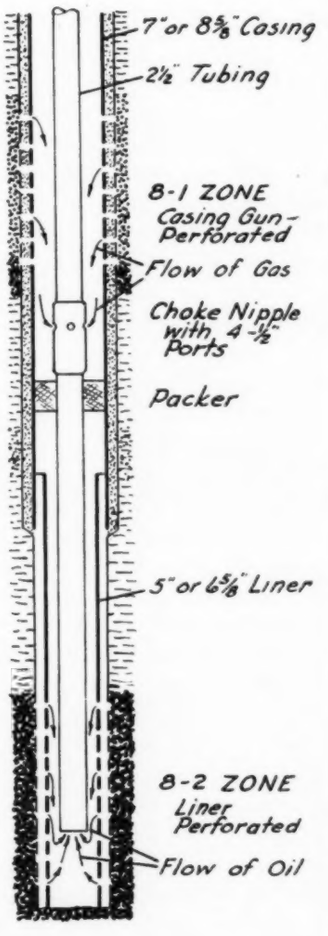
By WALLACE A. SAWDON
Pacific Coast and Foreign Editor

ALLOCATION of production from the Montebello field, California, is made according to the gas potential of a well when it is completed. This procedure is followed as a gas conservation measure and is under the supervision of the California State Mining Bureau, which applies a power factor formula in making the allocation. The gas production from each well is measured and the total gas production of the field is allocated to the individual operators on the basis of well potential in the same manner as oil is allocated by the State Oil Umpire. Montebello, however, is an oil field, so with the gas allowable for a well established, the operator strives, of course, to produce as much oil as possible with the allowable production of gas. The present total allowable for the field is approximately 90,000,000 cu. ft. per day and the greater part of the gas is treated at one of the natural gasoline plants serving the field.

Recent developments in the West Montebello field have been in the 8-1 and 8-2 zones with a more recent zone, the 8-3 Zone, now being penetrated. The deeper horizons in this field begin with the 5th Zone; some wells are drilled to produce from the 5th, Masser, and 6th zones, a number of these being later deepened to the 7th Zone. The bottom of the 5th Zone ranges from 5700 to 5800 ft. and that of the 6th Zone from 6700 to 6900 ft. Wells drilled through the 7th Zone are from 7400 to 7500 ft. in depth. The 8th Zones are not far below the 7th Zone and range from 7600 ft. (the total depth of some 8-1 Zone wells) to approximately 7800 ft. (the total depth of wells completed in the 8-3 Zone). The 7th Zone therefore is sometimes produced with the 8th Zone in wells when conditions make this advisable.

Production from the 8-1 and 8-2 zones in some parts of the field is being controlled by bottom-hole chokes to obtain the maximum oil from each well. The 8-1 Zone at the top of the structure yields a little oil with the gas and on the south flank sufficient oil is obtained to warrant its production without gas segregation. To the north, however, this sand produces considerable gas but very little oil. The 8-2 Zone makes enough gas to lift the oil produced from that zone but the allowable gas for wells completed in the 8-1 and 8-2 zones is usually more than the 8-2 Zone can produce. Gas, therefore, is added to the 8-2 Zone production from the 8-1 Zone to attain the allowable and the gas-lift effect of this added gas increases the oil production from the 8-2 Zone.

Fig. 1



A typical completion in the 8-2 Zone with production augmented by gas from the 8-1 Zone is shown in Fig. 1. In this well the casing is cemented through the 8-1 Zone and the liner, perforated opposite the 8-2 Zone, is hung in the casing, the 8-1 Zone being gun-perforated. In completing some wells, the liner is cemented through the productive zones and both zones gun-perforated. The tubing is made-up with a packer below the 8-1 Zone perforations. Immediately above this packer is a choke nipple that constitutes the outer chamber of a side-door removable bottom-hole choke and it is in this nipple that the choke is landed.

The choke is run into the well with running tool jars and sinker bar on a small wire line. When it is in position in the landing nipple it is automatically locked there and the running tool jars, sinker bar, and wire line withdrawn. The choke is removed with a pulling tool, which is also run-in on the wire line. Four ½-in. ports are made in the nipple for passage of fluid into the tubing and the choke itself is usually provided with two holes slanting upward through the body of the choke. The area of these holes governs the volume of flow into the tubing from above the packer. Production from below the packer may also be beaned by placing any desired orifice in the bottom of the choke body. At times when flow of fluid through the

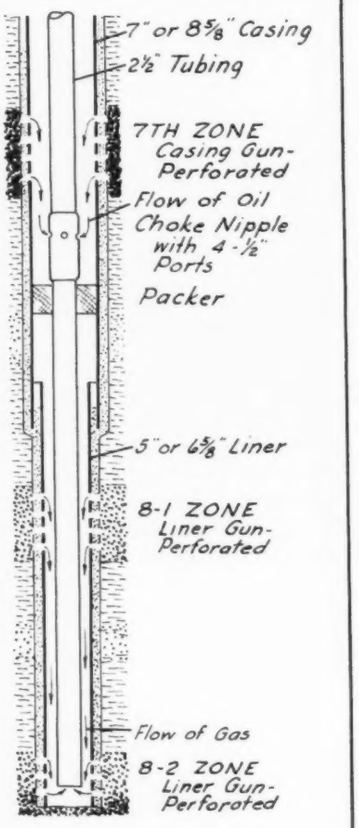


Fig. 2

side openings is to be cut off, a blind choke is set in the nipple. Packing between the choke and the landing nipple both above and below the ports prevents passage of fluid around the body of the choke.

In the wells being completed as shown in Fig. 1 the tubing is set approximately 10 ft. off bottom and oil from the 8-2 Zone enters the bottom of the tubing, being prevented by the packer from flowing upward through the annular space between the tubing and casing. Gas from the 8-1 Zone enters through the choke at a predetermined rate, which is controlled by the orifice size in the choke nipple. This flow of gas can be changed by removing the choke and replacing it with another having a different size opening.

In the above installation a higher gas zone was utilized to obtain a more efficient flow of oil from a lower zone. In some parts of the field even the 8-2 Zone has too much gas and not sufficient oil to make production entirely satisfactory. In wells such as those illustrated by Fig. 2, the 7th, 8-1, and 8-2 zones have all been cemented through; but after the 8th Zones were gun-perforated they were found to have preponderant gas production. When the 7th Zone is in condition to gun-perforate, oil can be taken from this zone and the gas from the zones below used to increase its flow.

The side-door choke in this installation is made with three ½-in. holes instead of two smaller ones and oil from the 7th Zone, after passing through the four holes in the choke nipple, flows freely into the tubing. A 4/64-in. bean is placed below the side-door ports to permit gas from the 8-1 and 8-2 zones to flow the oil coming from the 7th Zone. In cases where gas from the lower zones is not immediately necessary to produce the 7th Zone a blank bean is used to keep the gas below the choke nipple. Later, when gas for lifting is desired, the blank can be replaced with another bean of required opening.

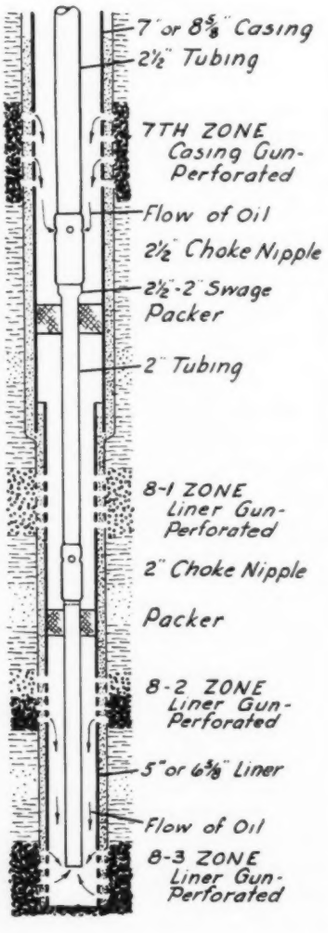
The gas in this case flows from the 8-1 and 8-2 zones and enters the bottom of the tubing, which is set in the lowest zone. The packer prevents flow of gas up the annular space between the tubing and casing and the bean limits the flow through the tubing to the amount necessary for effective flow of oil from the 7th Zone.

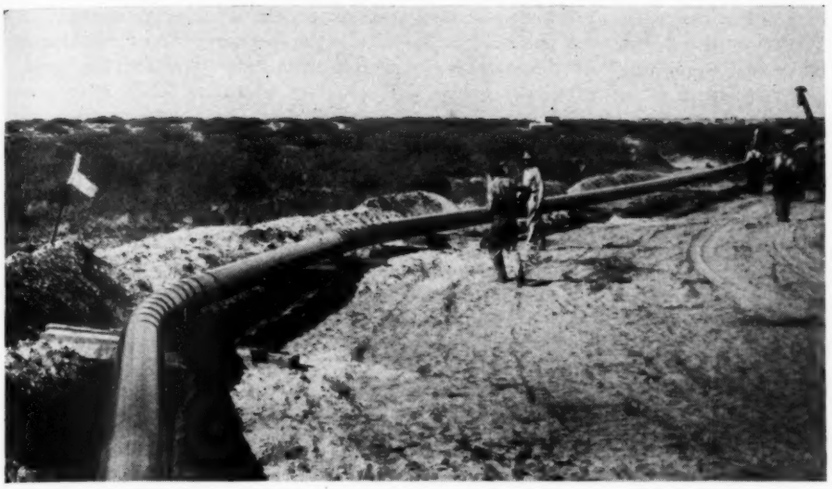
The 8-3 Zone, which is now being developed in the West Montebello field, gives indications of being a very prolific oil producer. Fig. 3 illustrates the most recent plan for producing that zone in conjunction with the 8-2 Zone and at the same time taking oil from the 7th Zone. With the method here illustrated the gas from the 8-1 Zone is preserved until its use is required but its gas potential is measured to obtain the proper allowable for the well.

All zones are cemented-through and then gun-perforated. The production string consists of 2-in. tubing through the 8th Zones and 2½-in. tubing from there to the surface. A 2-in. choke nipple and packer is set just below the 8-1 Zone and between the nipple and packer is a cast-iron disk. Immediately below the 7th Zone is a 2½-in. choke nipple, below that a 2½-in. by 2-in. swage nipple and below the swage a packer. When taking the gas potential a blank choke is set in the 2½-in. choke nipple to keep oil from entering the tubing from the 7th Zone. No choke is landed in the 2-in. choke nipple so gas from the 8-1 Zone flows freely into the tubing and is produced alone.

After the gas potential is measured, the 2½-in. choke is removed and the cast-iron disk broken. A choke with large side-door openings is then landed in the 2½-in. choke nipple and a choke without side openings is landed in the 2-in. nipple. This permits oil to flow from the 8-2 and 8-3 zones into the bottom of the tubing and from the 7th Zone through the side-door choke. Upon depletion of gas from the 8-2 and 8-3 zones the blind choke in the 2-in. nipple can be replaced by a choke with proper size side holes to admit gas from the 8-1 Zone and assist the flow of oil from the other zones.

Fig. 3





This view of a 14-in. oil pipe line recently constructed in New Mexico illustrates the smooth appearance of wrinkle bends

A PETROLEUM ENGINEER EXCLUSIVE FEATURE

By
F. C. HUTCHISON
Engineer, The Linde Air Products Company

Increasing Use of Wrinkle Bending in Pipe-Line Construction

Method permits fast, economical progress over rough terrain where many bends are required

MORE and more pipe-line construction companies are utilizing the time-saving and money-saving advantages of wrinkle bending pipe by the oxy-acetylene flame. The process greatly speeds the work of bending and line-up crews, and, on some jobs traversing extremely rough terrain when as many as 200 bends to the mile are required, wrinkle bending has resulted in an estimated saving of almost 1 cent per ft. in the cost of laying pipe as compared to other methods of pipe bending.

In addition to economy, wrinkle bending offers many other important advantages. Perhaps the most important is the fact that any amount of bend can be introduced into the pipe without unduly stressing or appreciably thinning the pipe wall on the outside of the bend. Furthermore, on the inside of the bend, compression squeezes the pipe so that the metal at the wrinkle is actually slightly thicker than the original wall. The wrinkles project outward, thus providing a full opening inside the pipe throughout the bend. Wrinkle bends, properly made, cause no flattening of the pipe or undesirable distortion, and offer no obstruction to the use of cleaning scrapers. These advantages are important in the fabrication of small piping around the refinery as well as in the construction of overland pipe lines.

F. C. HUTCHISON

was born in Montreal, Canada, and received his elementary education in Minneapolis, Minnesota—After several years' experience in the manufacture of radio specialties, he entered Massachusetts Institute of Technology to specialize in machine design—Graduated in 1927 with the degree of bachelor of science in mechanical engineering—After graduation he was employed by The Linde Air Products Company—Spent two years in fundamental research work and then was transferred to the Apparatus Development Section—Since 1932 he has served as engineer in process service work—Lives in Kansas City, Missouri.

The procedure for making wrinkle bends is comparatively simple and essentially the same for all size pipe, and independent of whether the requirements call for side bends, over bends, or sag bends. The oxy-acetylene flame is applied so that one or more narrow bands are heated at right angles to the pipe and extend about two-thirds the way around the pipe. When the heated area has been brought to the correct temperature, the pipe is then bent either by hand or by means of a tractor or bending rig until the heated sections buckle sufficiently to give the pipe the desired curvature. An over bend can be made by simply raising the pipe with a hitch at the point where the wrinkle is to be made until the desired angle is obtained. A sag bend is made by raising the end of the pipe joint. A horizontal pull at either end of the pipe or at the point of wrinkle produces a side bend. A combination horizontal and vertical bend can be made by simply controlling the direction of pull in each direction.

Wrinkle bending lends itself readily to correction, as too much bending in one or more wrinkles may be corrected simply by reheating and applying a reverse pull or sag. Because the bend occurs only at the point where the steel has been softened by heating, the pipe is not stressed as in cold bending.

Two blowpipes are used to bring the pipe wall to a cherry-red heat before the wrinkle is made

Large-capacity blowpipes designed for heavy heating operations are particularly suitable for wrinkle bending. As a rule, only one oxy-acetylene blowpipe is required for wrinkle bending pipe 6 in. or less in diameter. On larger pipe a more satisfactory bend is made by two blowpipes, one applied on each side of the pipe.

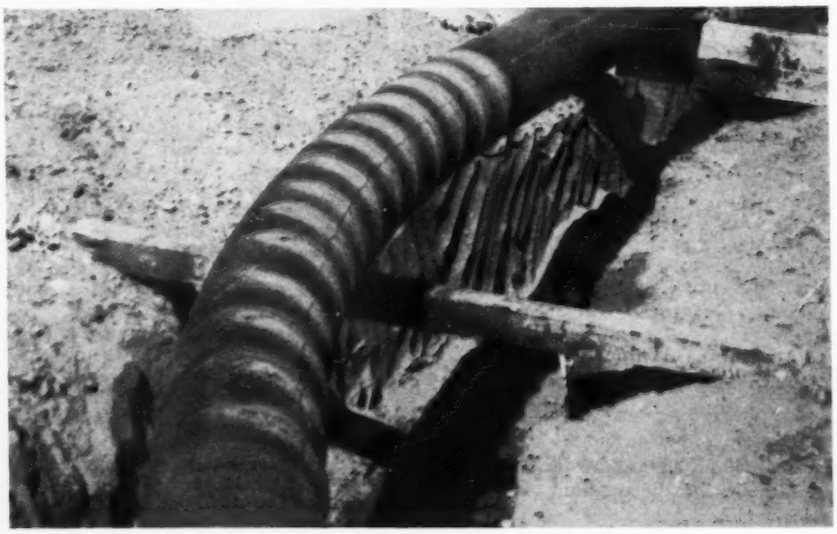
In heating the pipe, the oxy-acetylene flame of the blowpipe is adjusted to neutral and applied to the pipe surface. Bending can be started when the metal becomes a medium cherry color as seen under diffused light conditions. This represents a temperature of about 1200° F.

The width of the heated area should measure approximately 3 to 4 in. and should extend in both directions to include from two-thirds to three-fourths of the circumference of the pipe. This area should taper from its maximum width to points at both ends of the heated band. Within these limits the maximum width and length of the heated band should be determined by the size of the pipe and the degree of bend of the wrinkle.

Experience has indicated that for each wrinkle a bend of 5 to 7 deg. should be the maximum to which the pipe is bent in order to guard against distortion of the pipe near the wrinkle or against "pinching" of the wrinkle. The total bend at any particular point can be increased by making a series of wrinkles close to each other. The entire time required to make each wrinkle on, say, 8-in. pipe, should not be more than 2½ to 3 min. Best results can be obtained if the pipe is heated to the correct temperature and in the recommended manner. Insufficient heating causes flattening of the pipe and gives rise to difficulties in bending. Furthermore, after the bend is made, the pipe must not be allowed to cool too rapidly, for this may cause the pipe to become brittle. Another important factor is the composition of the flame, which must be neutral for this work. It requires no special skill, of course, to adjust an oxy-acetylene flame to neutral and to be able to detect when metal has been heated to a cherry red. Wrinkle bending, properly done, therefore, can contribute greatly to the speed and quality of pipe-line construction. It should be possible to obtain consistently good wrinkle bends that will meet all the service conditions for which the pipe itself is suitable, and that will lower the costs of construction whether the all-bell-hole or stovepipe methods of welding are employed.

When the band has been brought to the correct temperature, the pipe will be given a further bend to produce a wrinkle similar to the four already completed

Long, sweeping bends are made by a succession of closely-centered wrinkles, each providing a bend of approximately 5 deg.



P 501.72
P 214.

The Behavior of Oil and Gas Under High Pressures and Temperatures

Analyses of high-pressure gas-oil equilibria may indicate relative position of well in the reservoir and thus determine future drilling and proper methods of production

Part 1

By HARVEY T. KENNEDY
Gulf Research and Development Company

IMPROVEMENTS in drilling technique and drilling equipment, with consequent deeper wells, have forced those engaged in oil and gas production to consider an entirely new subject, the behavior of these products, oil and gas, under conditions of high pressure and temperature. As shallow production becomes exhausted, and especially if consumption of oil continues to increase, there is every reason to expect that the trend toward deeper drilling will continue.

Fig. 1 shows the depths of the deepest oil wells at various times since Col. Drake first struck oil at a depth of 69.5 ft., plotted against a uniform time scale. Throughout the history of the oil industry there has never been any reason to suppose that the occurrence of oil and gas was limited to shallow depths, so that it is evident that ability rather than desire has been the limiting factor in the depths attained.

Rapid improvement in materials and technique is indicated by recent successes, and thus it is reasonable to assume that this trend will continue, perhaps at an accelerated pace. It is understood that preparations are now being made in California to drill to 20,000 ft.

The pressure and temperature encountered at any particular depth vary widely with the locality, and this is especially true of the temperature. Average values for fields when first drilled, based on a temperature gradient of 15°F. and a pressure gradient of 434 lb. per 1000 ft., are shown in Fig. 2. Oil and gas exhibit abnormal behavior at pressures as low as 2000 lb., corresponding to about 4500 ft.; and it is seen from Fig. 1 that our subject is by no means academic. Fig. 3 shows behavior characteristic of all pure materials that can be vaporized. Beginning with a gas at temperature T_1, if it be compressed at constant temperature, a pressure is reached at which liquid begins to form. This pressure is termed the vapor pressure of the liquid at the temperature T_1. Further decrease in volume results in liquefaction without increase in pressure until the vapor has disappeared and the system consists only of liquid. Further decrease in volume can be accomplished only by sharply increasing the pressure, because of the well-known fact that liquids are but slightly compressible.

HARVEY T. KENNEDY

has received a bachelor's degree in chemistry from Cornell University and a degree of Doctor of Philosophy from Johns Hopkins—His first employment was with the Municipal Testing Laboratory, Rochester, New York—From there he went to the U. S. Bureau of Standards at Washington, D. C., where he was assistant and associate oil technologist and associate scientist—For the last ten years he has been with the Gulf Research and Development Company, Pittsburgh, Pennsylvania, where he is in charge of petroleum production chemistry research.

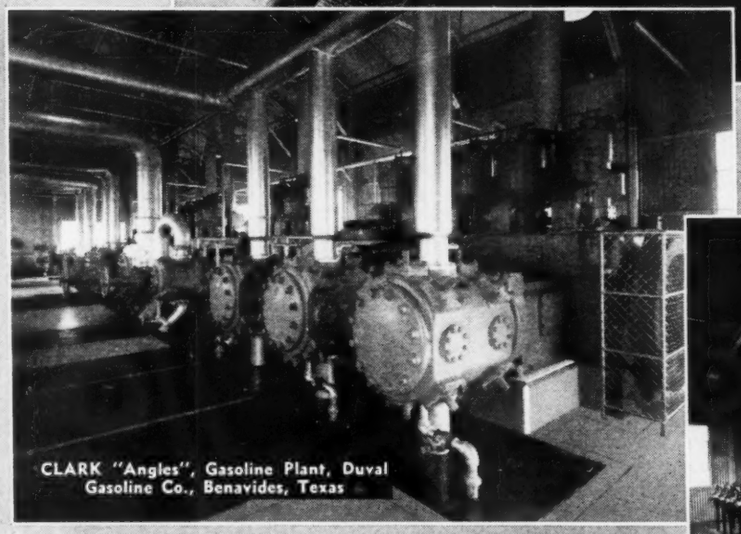
If the system is raised to higher temperatures, as T_2 and T_3, and again compressed, the same general behavior is observed. The range of volume, however, over which the pressure is constant becomes less as the temperature increases, until finally, at T_4, we find an isotherm at which the "flat" just vanishes. This temperature is called the critical temperature, and the pressure at which the "flat" occurs is the critical pressure. Above the critical temperature, no liquid can be observed, no matter how great the pressure, although the compressed gas may assume many of the properties of liquid. It is possible to pass from liquid to vapor, as these terms were used above in discussing the T_1 isotherm, without observing any discontinuity in properties whatever, by merely avoiding the area in Fig. 3 that is enclosed by the dotted line. The exact state of the material at the point A can be reached by starting at T_1, on the vapor side, by increasing the temperature to T_5 and then compressing, or by starting with liquid at T_1, raising the temperature and expanding. In neither of these processes is there any break in the continuity, and the material would ordinarily be called vapor or liquid, depending only on the direction from which approached, and the terms become meaningless. Even within the dotted area, where liquid and vapor can exist together and be distinguished, their properties become more alike. Thus liquids near the critical point become highly compressible (infinitely compressible at the critical point) and of lower density, and vapors assume densities and solvent powers ordinarily associated only with liquids.

In Fig. 4 is shown the variation of any property, such as density, of liquid and vapor at high pressures. All properties, such as refractive index, viscosity, or solvent power for any material, can be similarly exhibited, and can be shown to be continuous variables over the entire range of pressure at which liquid and vapor can coexist.

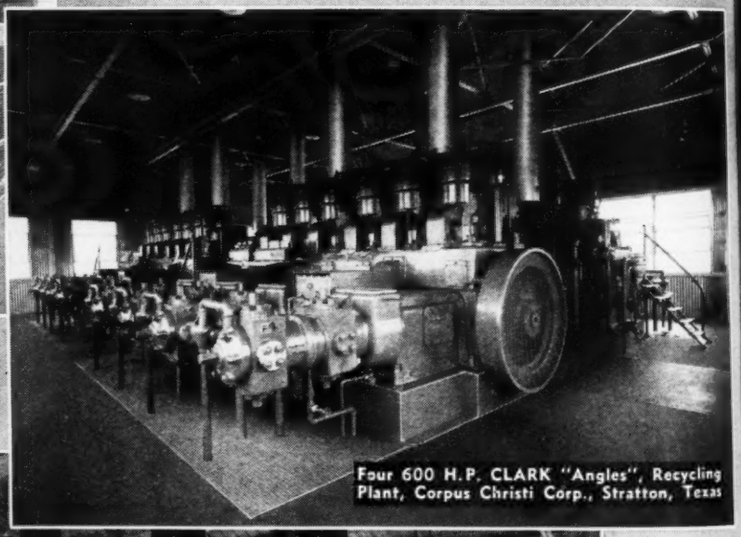
The property of hydrocarbon gas under high pressure and temperature

(Continued on Page 120)

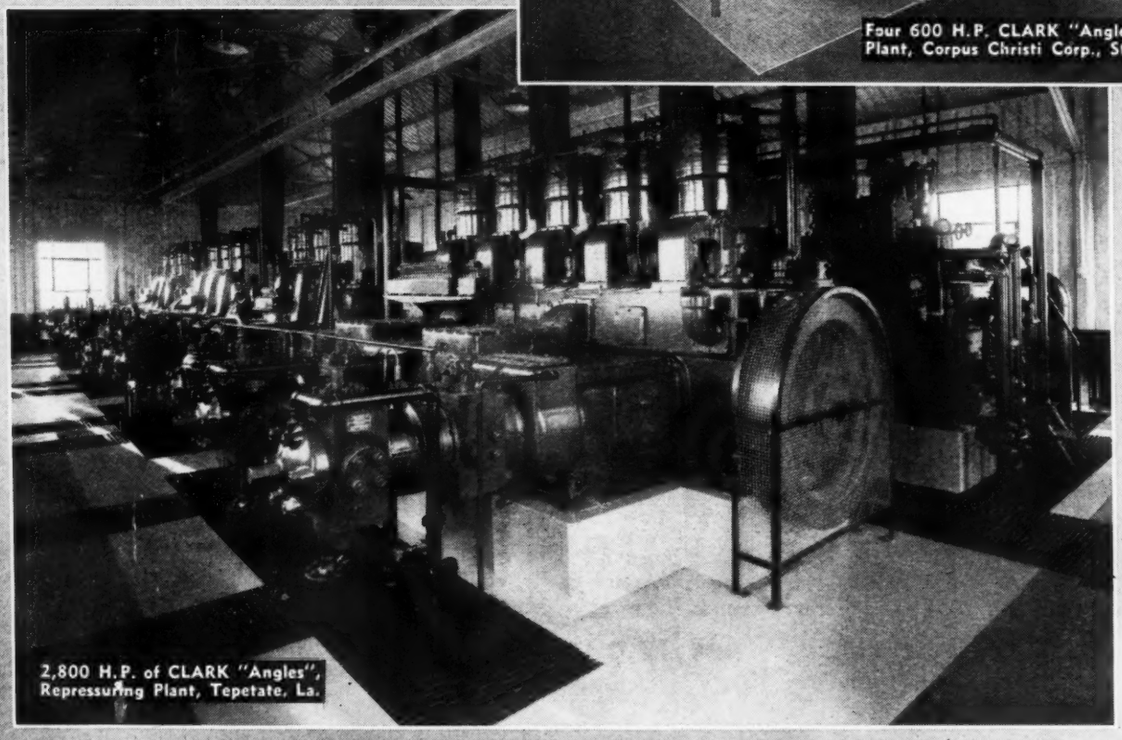
Five 800 H.P. CLARK "Angles", Coastal Recycling Co., Banquete, Texas



CLARK "Angles", Gasoline Plant, Duval Gasoline Co., Benavides, Texas



Four 600 H.P. CLARK "Angles", Recycling Plant, Corpus Christi Corp., Stratton, Texas



2,800 H.P. of CLARK "Angles", Repressuring Plant, Tepetate, La.

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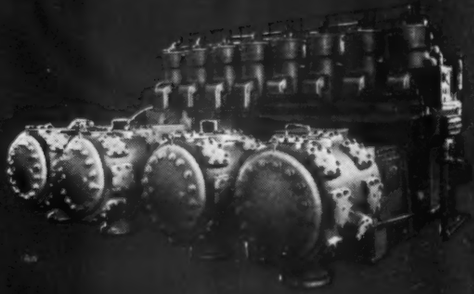
Power, efficiency and reliability equal to the famous CLARK Horizontal Compressor, combined with important savings in installation and operating costs, explain this success. CLARK "Angles" are shipped assembled, reducing transportation and erection costs. They require less than half the concrete for foundations and occupy about half the floor space. And like all CLARK Compressors, their patented Super-2-Cycle Fuel Injection saves one-third in fuel.

These savings deserve your attention. Our nearest sales office will be glad to go into details.



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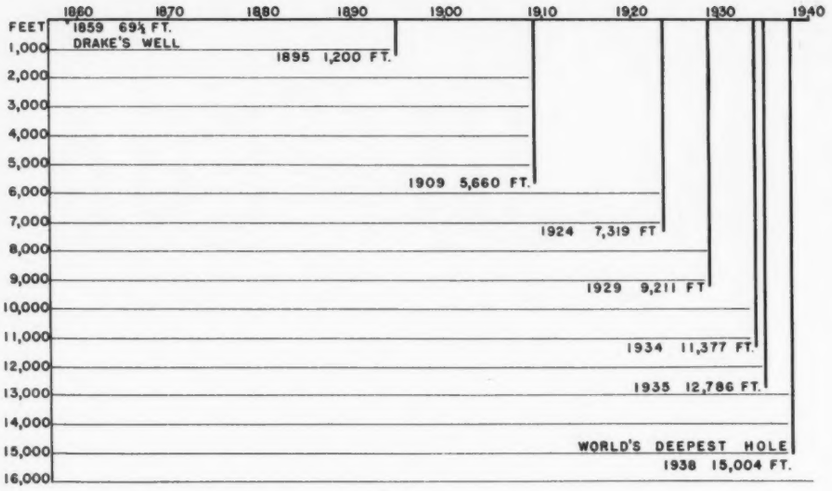


Fig. 1. Sketch showing depths of world's deepest oil wells

(Continued from Page 117)

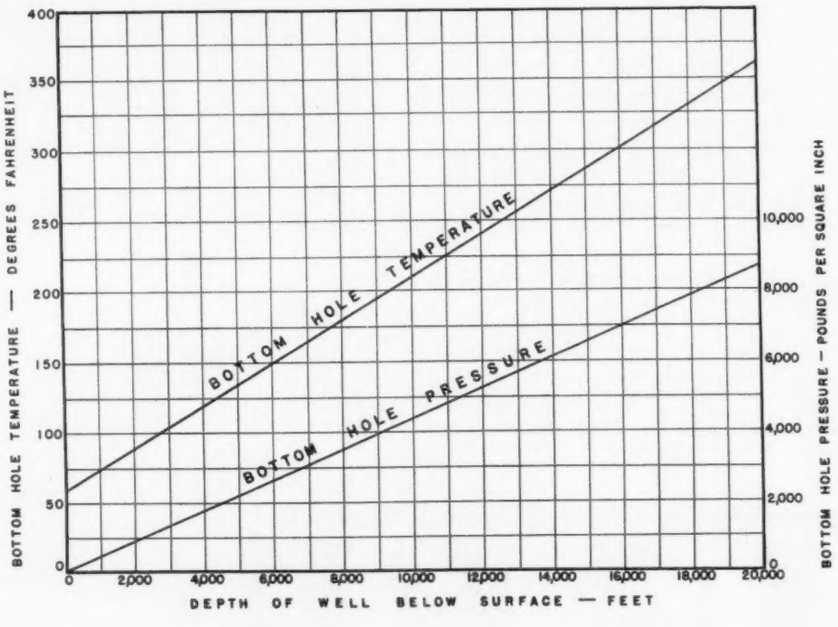
that concerns us most is the solvent power, as solvent power is responsible for the retention of comparatively heavy, non-volatile oil in gaseous mixtures. Fig. 5 is a photograph of two glass capillary tubes at 70°F. The capillary passages in both tubes contain Kettleman Hills oil in the same concentration as it occurs in place in the upper portion of the Kettleman Hills reservoir. The tube on the right contains no gas, but the left tube is under high pressure of gas of the same composition as that obtained from the formation. The concentration is adjusted so that, when the temperature is raised to 200°F., 3000-lb. pressure will be exerted, which is approximately the original pressure existing in the formation. It will be noted that the volume of the oil in both tubes is substantially the same, indicating that under these conditions, solution of oil in gas is a minor effect.

Fig. 6 shows the same tubes at 200°F. It will be noted that the oil is substantially unchanged in the tube containing no gas, but the gas at 200°F. and 3000 lb. has entirely dissolved the oil. These tubes were prepared in 1930 and to the writer's knowledge, were the first demonstration of the physical state in any reservoir producing "distillate." The results showed conclusively that the well was bottomed in a gas cap, and no oil as such was entering the well bore. This well has subsequently been plugged and wells lower down the structure are producing heavy oil with normal gas-oil ratios.

Due to the complex composition of oil and gas, and the failure of various laws, otherwise valid at low pressure, to represent the true state of affairs adequately, there is no general method of calculating or predicting equilibrium conditions above, say, 2000-lb. pressure. For special cases, involving simplified systems, accurate data are at hand. For example, Sage, Lacey and Schaafsma *(A.P.I. Production Bulletin* 212, p. 119, 1933) have examined various mixtures of methane and propane, and have expressed their results in the form shown in Fig. 7, in which pressure is plotted against temperature.

If at any temperature, T_1, below the critical point of the mixture, a sufficiently low pressure is chosen, all

Fig. 2. Average bottom-hole conditions



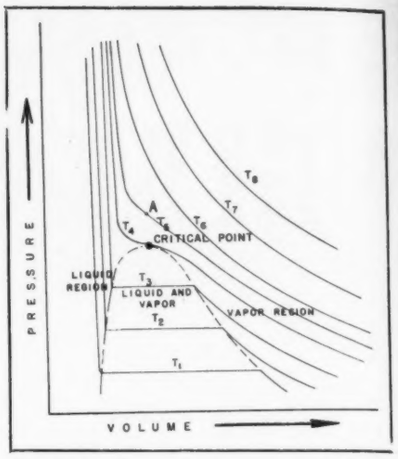
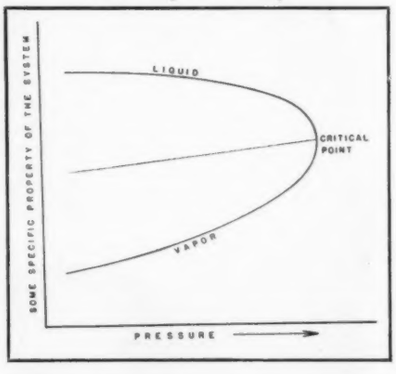


Fig. 3. Isotherms for a pure substance

Fig. 4. Generalized curve for saturated vapor and liquid



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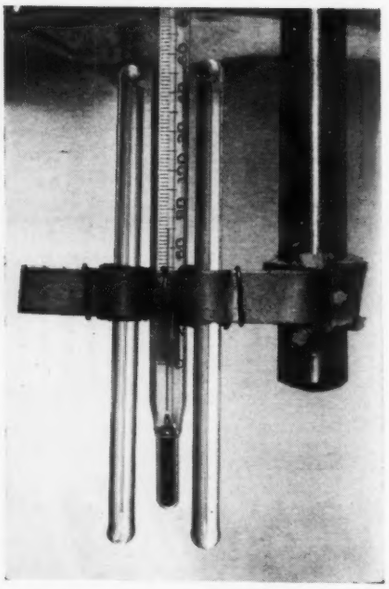
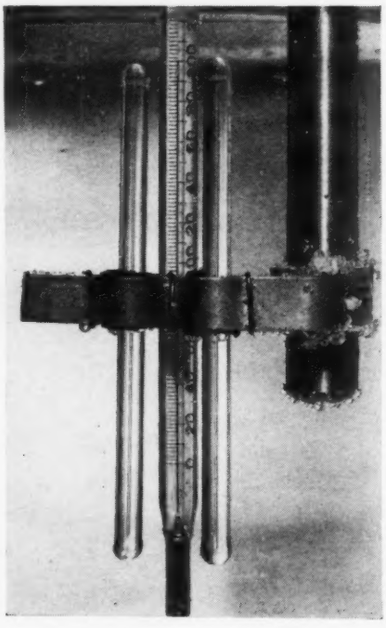


Fig. 5. Two capillary tubes at a temperature of 70°F.

of the mixture will be in the vapor form. As the pressure is increased, a point, P_1, will be reached at which a small amount of liquid forms. The liquid will consist largely of the component of lower volatility propane, leaving the vapor richer in volatile methane. As the pressure is increased, further liquefaction takes place until at P_2 the entire system is liquid.

Fig. 6. Same tubes as in Fig. 5 but at 200°F.



For each mixture, there is a specific temperature, called the critical temperature of the mixture, at which, when the vapor is compressed as above, the liquid meniscus disappears in the center of the tube, and at the point of disappearance, the liquid and vapor compositions are identical. The critical pressure and temperature are in this respect analogous to those of a pure compound. The critical temperature, however, is not generally the highest temperature at which liquid can be in equilibrium with its vapor, this latter point being shown at C′, and being termed the critical condensation temperature, or for short the "cricondentherm," of the particular mixture.

Between the "cricondentherm" and the critical temperature, expansion at

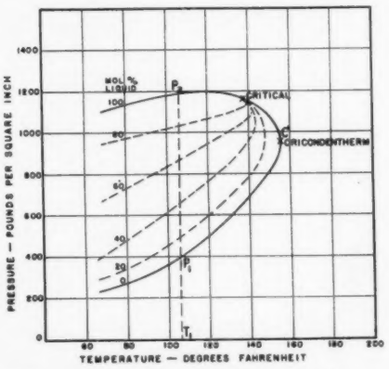


Fig. 7. Phase diagram for 40 mol percent methane, 60 percent propane *(after Sage, Schaafsma, and Lacey)*

constant temperature will cause the condensation of liquid, because the solvent power of the vapor for the heavier components decreases more rapidly due to decrease in density than it increases due to increase in volume. As this action is in the reverse direction from that observed at low pressures, it has been called "retrograde condensation" by early investigators working entirely with volatile mixtures.

The above phenomenon is by no means limited to volatile materials, such as methane and propane, although at least one component must resist condensation in order to have vapor at high pressures. Thus, Villard, *(Comp. Rend. 120,* 182, 1895; *Chemical News 78,* 297, 309, 1898) observed high solubility of solid iodine in both liquid and highly compressed gaseous carbon dioxide, and found methane to be a particularly good solvent

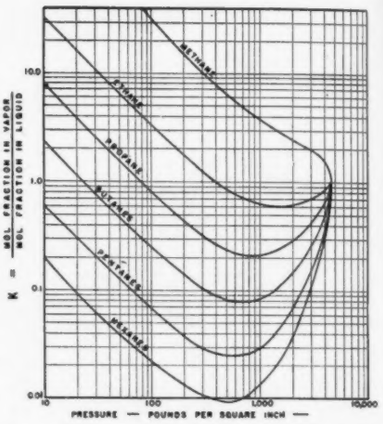


Fig. 8. Equilibrium constant vs. pressure at 40°F. *(after Katz and Hachmuth)*

for many materials, both solid and liquid. Iodine, camphor, and paraffin dissolved readily when methane was compressed, and precipitated when the pressure was released. Many investigators have shown that this behavior cannot be accounted for by Poynting's law, which relates the vapor pressure of a liquid to the pressure of an inert gas above it. When one considers that the density of the gas in place in Fox field, Oklahoma, for example, is 0.82 (equivalent to 40° A.P.I.), no explanation on the basis of the perfect gas laws appears necessary or sufficient, and all of them have failed, as they would if applied to the phenomenon of solution of liquids or solids in liquids under ordinary conditions.

Katz and Hachmuth *(I.E.C. 29,* 1072, 1937) have examined one mixture of oil and gas from the Oklahoma City field in great detail. Their results at one temperature are shown in Fig. 8. The ordinate is the equilibrium constant, K, defined as the ratio of the mol percentage of any constituent in the gas phase to the mol percentage in the liquid phase. The abscissa is pressure. At low pressure, where Raoult's law and Dalton's law hold with some accuracy, the equilibrium constant may be shown to equal $\frac{P_o}{P}$, where P_o is the vapor pressure of the pure liquefied component; under these conditions the plot has general validity. Even at pressures as low as 200 lb., however, curvature is observed in these lines, and at 500 to 1500 lb. most of the lines reverse their direction.

EDITOR'S NOTE: This article will be concluded in an early issue.

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P 615.1
P 621.

Laws of Fluid Flow In Rough Pipes

Experimental work extends the determination of friction factor, f, into the region of flow conditions of existing high-pressure transmission lines

PART 3

By J. NIKURADSE

THE most simple relations, as we have already seen, are produced in the third range, where the coefficient of resistance is independent of the Reynolds Number, and therefore depends only upon the relative roughness. This dependence may be represented by the simple formula:

$$\lambda = \frac{1}{(1.74 + 2\log\frac{r}{k})^2} \quad . \quad . \quad (4)$$

In order to test this formula experimentally, the quantity $\frac{1}{\sqrt{\lambda}}$, depending on log r/k, was plotted in Fig. 7, wherein it is shown that the straight line:

$$\frac{1}{\sqrt{\lambda}} = 1.74 + 2\log\frac{r}{k} \quad . \quad . \quad (5)$$

runs through these points in close approximation. Now, in order to graph the entire range of the tested Reynolds Numbers, the magnitude $\frac{1}{\sqrt{\lambda}} - 2\log r/k$ depending on $\log\frac{v^* k}{\nu}$ may be plotted. This magnitude is particularly suitable for dimensional purposes, since the values are characteristics of the conditions of the wall. Instead of $\frac{v^* k}{\nu}$, the magnitude $\log \mathrm{Re}\sqrt{\lambda} - \log r/k$, which is here more appropriate, may also be applied, as can be seen from the following. That is:

$$\lambda = \frac{dp}{dx}\frac{4r}{\rho\bar{u}^2} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The relation between the shearing stress τ_0 and the coefficient of resistance λ is given as follows: From the state of equilibrium in a fluid cylinder of length dx and radius r we get:

$$2\pi r\tau_0 = \frac{dp}{dx}\pi r^2$$

or in the case of (1):

$$\frac{\tau_0}{\rho} = \lambda\frac{\bar{u}^2}{8} \quad . \quad . \quad . \quad . \quad . \quad (6a),$$

or

$$\sqrt{\lambda} = 2.83\frac{v^*}{\bar{u}} \quad . \quad . \quad . \quad . \quad . \quad (6b),$$

where $v^* = \sqrt{\frac{\tau_0}{\rho}}$ denotes the shearing stress velocity. From this we obtain

$$\mathrm{Re}\sqrt{\lambda} = 5.66\frac{v^* r}{\nu}$$

and

$$\log(\mathrm{Re}\sqrt{\lambda}) - \log\frac{r}{k} = \log\left(5.66\frac{v^* k}{\nu}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7a)$$

or

$$\log\frac{v^* k}{\nu} = \text{constant} + \log(\mathrm{Re}\sqrt{\lambda}) - \log\frac{r}{k} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7b)$$

From equation (5):

$$\frac{1}{\sqrt{\lambda}} - 2\log\frac{r}{k} = 1.74 \quad . \quad . \quad (5a);$$

consequently, $\frac{1}{\sqrt{\lambda}} - 2\log r/k$ in the quadratic region of resistance is a constant, but in the other ranges it varies with the Reynolds Number. We have shown above why we chose the magnitude:

$$\log(\mathrm{Re}\sqrt{\lambda}) - \log r/k,$$

as the abscissa in our graph, instead of $\log(\mathrm{Re}\sqrt{\lambda})$ as in the case of the smooth pipe. Equation (5a), therefore, may be written thus:

$$\frac{1}{\sqrt{\lambda}} - 2\log\frac{r}{k} = f\left(\log\frac{v^* k}{\nu}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8).$$

Consequently, the previous nondimensional value $\eta = \frac{v^* k}{\nu}$ is now the determinative magnitude as was to be expected after examining the dimensions. This formula, which has been determined experimentally, is represented in Fig. 8, for five relative roughnesses, data for which are tabulated in Tables 2 to 7.

The sixth relative roughness was omitted, since in this case the assumption of geometrical similarity was evidently not fulfilled. We now see that a smooth curve can be drawn approximating all experimental points.

Range I, in which there is as yet no roughness effect exerted on the resistance and in which, therefore, all tubes react as smooth ones, is represented in this graph by the formula:

$$\frac{1}{\sqrt{\lambda}} - 2\log\frac{r}{k} = 0.8 + 2\log\frac{v^* k}{\nu} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

whereby the function f in equation (8) is determined. The explanation for the experimental points lying below this straight line is found in the fact that at these small Reynolds Numbers a viscosity effect still exists, so that the curve of equation (3) is not accurately followed. The former range II, the transitionary range, is represented in Fig. 8 by a curve that first ascends, then is horizontal, and finally descends. For subsequent calculations the curves are drawn closely together by means of three straight lines, not shown[13] in Fig. 8. The previous range III, which follows the curve of quadratic resistance, lies in this diagram

(Continued on Page 127)

Perhaps no single work, since Weymouth's, has contributed so much of practical value to the knowledge of flow conditions in pipe lines as this paper by Nikuradse. Appearing in *Forschungsheft*, publication of Verein Deutsch Ingenieurs (German Society of Engineers) in 1932, it has been unavailable to American engineers except in the German version. Publication, even seven years after its appearance in Germany, is justified as an answer to the many requests from engineers in this country who desire to avail themselves of the data contained herein.

Due acknowledgment is hereby given to the Panhandle Eastern Pipe Line Company, 90 Broad Street, New York, New York, for permission to publish the English translation of the paper.

[13] *Vgl. L. Prandtl:* Reibungswiderstand. Hydrodynamische Problems des Schiffsantriebs, herausgeg. v. *G. Kempf* u. *E. Förster*, Berlin 1932, S. 87—*L. Prandtl:* Neuere Ergebnisse der Turbulenzforschung. Z. VDI Bd (1933) No. S. 105.

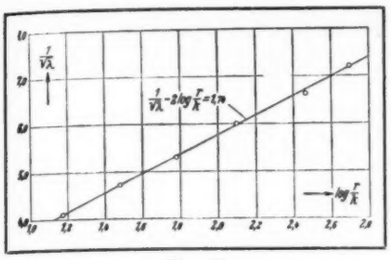


Fig. 7

$\frac{1}{\sqrt{\lambda}}$ depends on log r/k

(Continued from Page 124)

above $\log \frac{v^* k}{\nu} = 1.83$ and equation (5a) corresponds to it.

These straight lines may be represented by equations of the type:

$$\frac{1}{\sqrt{\lambda}} - 2 \log \frac{r}{k} = a + b \log \frac{v^* k}{\nu} \quad \ldots\ldots\ldots (10)$$

in which the constants a and b still depend on $\frac{v^* k}{\nu}$ in the following manner:

$$\frac{1}{\sqrt{\lambda}} - 2 \log \frac{k}{r} = 1.18 + 1.13 \log \frac{v^* k}{\nu}$$

for $0.55 \leqq \log v^* k \leqq 0.85$

$$\frac{1}{\sqrt{\lambda}} - 2 \log \frac{k}{r} = 2.14$$

for $0.85 \leqq \log v^* k \leqq 1.15$

$$\frac{1}{\sqrt{\lambda}} - 2 \log \frac{k}{r} = 2.81 - 0.588 \log \frac{v^* k}{\nu}$$

for $1.15 \leqq \log v^* k \leqq 1.83$

Evidently, each individual part of the straight line is represented by:

$$\lambda = \frac{1}{(a + b \log \frac{v^* k}{\nu} + 2 \log \frac{r}{k})^2} \quad \ldots\ldots\ldots\ldots (11)$$

2. Velocity distributions. Measurement of the velocity distributions was conducted in tubes with diameters of 2.5 cm., 5cm., and 10 cm., in which the Reynolds Numbers were approximately between 10^4 and 10^6. (Editor's note: Nikuradse's original data are presented in Tables 8 to 13, inclusive.) Since the velocity distributions were symmetrical, half had to be used in calculation. In order to show clearly the dependence of the velocity distribution on the quantity r/k, a nondimensional graph of the formula is selected:

$$\frac{u}{U} = f\left(\frac{y}{r}\right) \quad \ldots\ldots (12)$$

in which u denotes the temporary velocity, U is the maximum velocity, y is the distance from the wall, and r is the tube radius. This relation has been indicated in Fig. 9 for the smooth tube and for velocity distributions at various relative roughnesses, which lie within the region of the quadratic resistance curve. From this graph it may be noted that as the relative roughness increases, the velocity distributions become more acute. The previous experiments with the smooth pipe, however, have shown that with an increase of the Reynolds Number the velocity distributions become more complete.

A very simple law for the velocity distributions in the rough tubes, which have just been discussed, may be illustrated by the following graphs:

In Fig. 10 the nondimensional velocity u/v^*, dependent on y/r, is indicated. In this case v^* denotes the shearing stress velocity previously introduced, $v^* = \sqrt{\frac{\tau_0}{\rho}}$. From this graph it may be seen that the velocity distributions, regardless of the parts near the wall, are congruent to each other. The von Kármán graph:

$$\frac{U - u}{v^*} = f \frac{y}{r}$$

allows the congruent curves to unite in one single line (see Fig. 14). Similarly the velocity distributions of the different relative roughnesses practically coincide in one curve, if the nondimensional magnitude u/v^* is plotted as dependent on log y/k. It is obvious that all measured data lie perfectly on one straight line, which, however, refers only to velocity distributions that are in the field of the quadratic resistance curve. (See Fig. 11). This straight line is represented by the equation:

$$\frac{u}{v^*} = 8.48 + 5.75 \log \frac{y}{k} = A + B \log \frac{y}{k} \quad \ldots\ldots (13)$$

In order to reach the universal velocity distribution in a smooth pipe, we have formerly, in accordance with Prandtl[14], introduced the nondimensional wall distance $\eta = y \frac{v^*}{\nu}$ produced by the shearing stress velocity v^* and thereby obtained the following formula for the universal distribution of velocity:

$$\frac{u}{v^*} = \phi = 5.5 + 5.75 \log \eta \quad \ldots\ldots (14)$$

If we plot the relation $\phi = f(\log \eta)$ also for rough tubes, then we obtain Figs. 12a to 12f; in each case shown, a straight line results for the nondimensional velocity. Each graph represents a certain relative roughness and the various Reynolds Numbers indicated; Fig. 12a represents the smallest roughness r/k = 507, Fig. 12b represents the next higher, and so on. Furthermore, in each diagram the velocity distribution of the smooth pipe was drawn according to equation 14. The experimental data plotted on this straight line are not measured in a smooth, but in a rough, pipe at so small a Reynolds Number that the effect of roughness has not yet become noticeable. At a certain relative roughness these straight lines are displaced by the increase of the Reynolds Number, parallel to the straight line of the smooth pipe. A more accurate observation of the individual series measured reveals that the points determined close to the walls (small values of $\log \eta$), as well as the points close to the axis, (large values of $\log \eta$), are situated somewhat above the straight line.

In the field of the quadratic curve, A has a constant value, according to equation 13. Within the transitionary regions I and II, however, A is dependent on the Reynolds Number ($Re = \frac{\bar{u}\, 2r}{\nu}$) and on the relative roughness k/r, in such a manner that A essentially depends only upon the product $\left(Re \sqrt{\lambda} \frac{k}{r}\right)$, (see equation 7a). In accordance with the previous equation (6b):

$$\sqrt{\lambda} = 2.83 \frac{v^*}{\bar{u}}$$

so that

$$Re \sqrt{\lambda} \frac{k}{r} = 5.66 \frac{v^* k}{\nu}$$

This results, therefore, in a relation of the form:

$$A = \frac{u}{v^*} - 5.75 \log \frac{v}{k} = f\left(\log \frac{v^* k}{\nu}\right) \quad \ldots\ldots\ldots\ldots (15)$$

In order to be able to determine the magnitude A for each velocity profile, the magnitude $\frac{u}{v^*} - 5.75 \log y/k$ for every point of a profile must first be determined from Figs. 12a to 12e and plotted as a function of y/r. From this plotting, A will be determined for the corresponding profile by taking the specific mean wall distances into consideration. On the one hand, y cannot be determined exactly for the points near the wall because of viscosity effect, while on the other hand, systematic deviations occur for the points close to the axis. The magnitude A, thus determined for all velocity profiles is then plotted as a function of $\log \frac{v^* k}{\nu}$ (see Fig. 13). The path of the curve A as a function of $\log \frac{v^* k}{\nu}$ is quite similar to the dependence formerly established in connection with the

[14] *L. Prandtl:* Zur turbulenten Strömung in Rohren and längs Platten. Ergebn. Aerodyn. Versuchsanst. Göttingen, 4. Lief. 1932 S. 18.

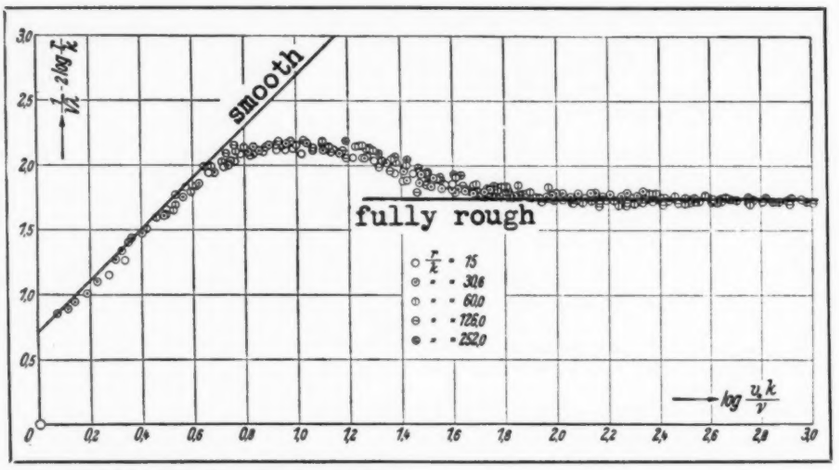


Fig. 8
$\frac{1}{\sqrt{\lambda}} - 2 \log \frac{r}{k}$ depends on $\log \frac{v^* k}{\nu}$

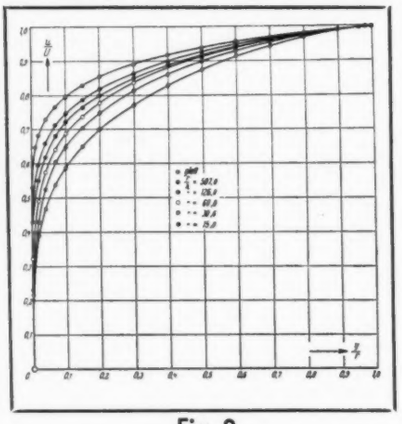


Fig. 9
u/U depends on y/r in the field of the quadratic resistance curve
Note: The German word "glatt" means "smooth" in English

resistance curve, where:

$$\frac{1}{\sqrt{\lambda}} - 2 \log r/k$$

was plotted depending on $\log \frac{v^* k}{\nu}$ (equation 8).

The calculated proof of this relation is also obtained by the same observation as in the smooth pipe[15]. In accordance with equation (13):

$$\frac{u}{v^*} = A + B \log \frac{y}{k} \quad \ldots\ldots \quad (16a)$$

or, if this equation is expressed for the tube center, then $u = U$ and $y = r$,

$$\frac{U}{v^*} = A + B \log \frac{r}{k} \quad \ldots\ldots \quad (16b)$$

If the magnitude $\frac{U - \bar{u}}{v^*} = \beta$. (17a) is determined from the equation: $\frac{U - u}{v^*} = f\,(y/r)$ by integration through plotting $\frac{U - u}{v^*}$ as a function of $(y/r)^2$, we obtain $\beta = 3.75$.

In accordance with equation (17a)

$$U = \bar{u} + \beta v^* \quad \ldots\ldots\ldots \quad (17b)$$

and in accordance with equation (6b) the relationship is given between the resistance coefficient λ and the mean velocity $\bar{u}$ by:

$$\bar{u} = \frac{2.83}{\sqrt{\lambda}} v^* \quad \ldots\ldots \quad (18)$$

If we insert equation (18) in equation (17b), we obtain on dividing by v^*:

$$\frac{U}{v^*} = \frac{2.83}{\sqrt{\lambda}} + \beta$$

and consequently according to equation (16b):

$$\frac{2.83}{\sqrt{\lambda}} = A + B \log \frac{r}{k} - \beta \ldots \quad (19a)$$

or with $B = 5.75$:

$$\frac{2.83}{\sqrt{\lambda}} - (5.75 \log \frac{r}{k} - \beta) = A. \quad (19b)$$

In equations (15) and 19b) we have the required relation between the velocity distribution and the resistance curve, which is thus expressed:

$$\frac{u}{v^*} - 5.75 \log \frac{y}{k} = \frac{2.83}{\sqrt{\lambda}} - \left(5.75 \log \frac{r}{k} - \beta\right) = f\left(\log \frac{v^* k}{\nu}\right) \ldots\ldots \quad (20)$$

In Fig. 13, besides the values of A calculated according to equation (15) from the velocity distributions, the values estimated according to equation (19b) and the resistance curve are likewise plotted. The agreement of the values of A, determined by these two methods, is satisfactory.

The curve A can be represented by a polygonal diagram as a function of $\log \frac{v^* k}{\nu}$ exactly as in Fig. 8. In the range of the resistance curve where there is as yet no effect of viscosity, the curve of the smooth pipe applies, that is:

$$\text{when } 0 \leqq \log \frac{v^* k}{\nu} \leqq 0.55 : A = 5.5 + 5.75 \log \frac{\nu}{v^* k} \quad \ldots\ldots\ldots \quad (21a)$$

The transitional region from the resistance curve of the smooth pipe to the quadratic resistance curve of the rough pipe is divided into three ranges:

$$\text{I. } 0.55 \leqq \log \frac{v^* k}{\nu} \leqq 0.85 : A = 6.59 + 3.5 \log \frac{v^* k}{\nu} \quad \ldots\ldots\ldots \quad (21b),$$

$$\text{II. } 0.85 \leqq \log \frac{v^* k}{\nu} \leqq 1.15 : A = 9.58 \quad \ldots\ldots\ldots\ldots \quad (21c),$$

$$\text{III. } 1.15 \leqq \log \frac{v^* k}{\nu} \leqq 1.83 : A = 11.5 - 1.62 \log \frac{v^* k}{\nu} \quad \ldots \quad (21d),$$

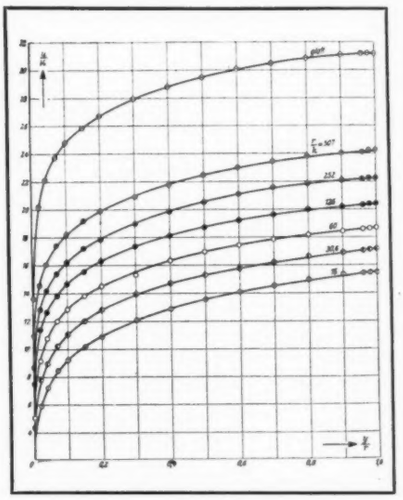


Fig. 10
u/v* depends on y/r

and finally, in the range of the quadratic resistance curve, we have:

$$\text{when } \log \frac{v^* k}{\nu} > 1.83 : \quad A = 8.48 \quad \ldots\ldots\ldots\ldots\ldots \quad (21e)$$

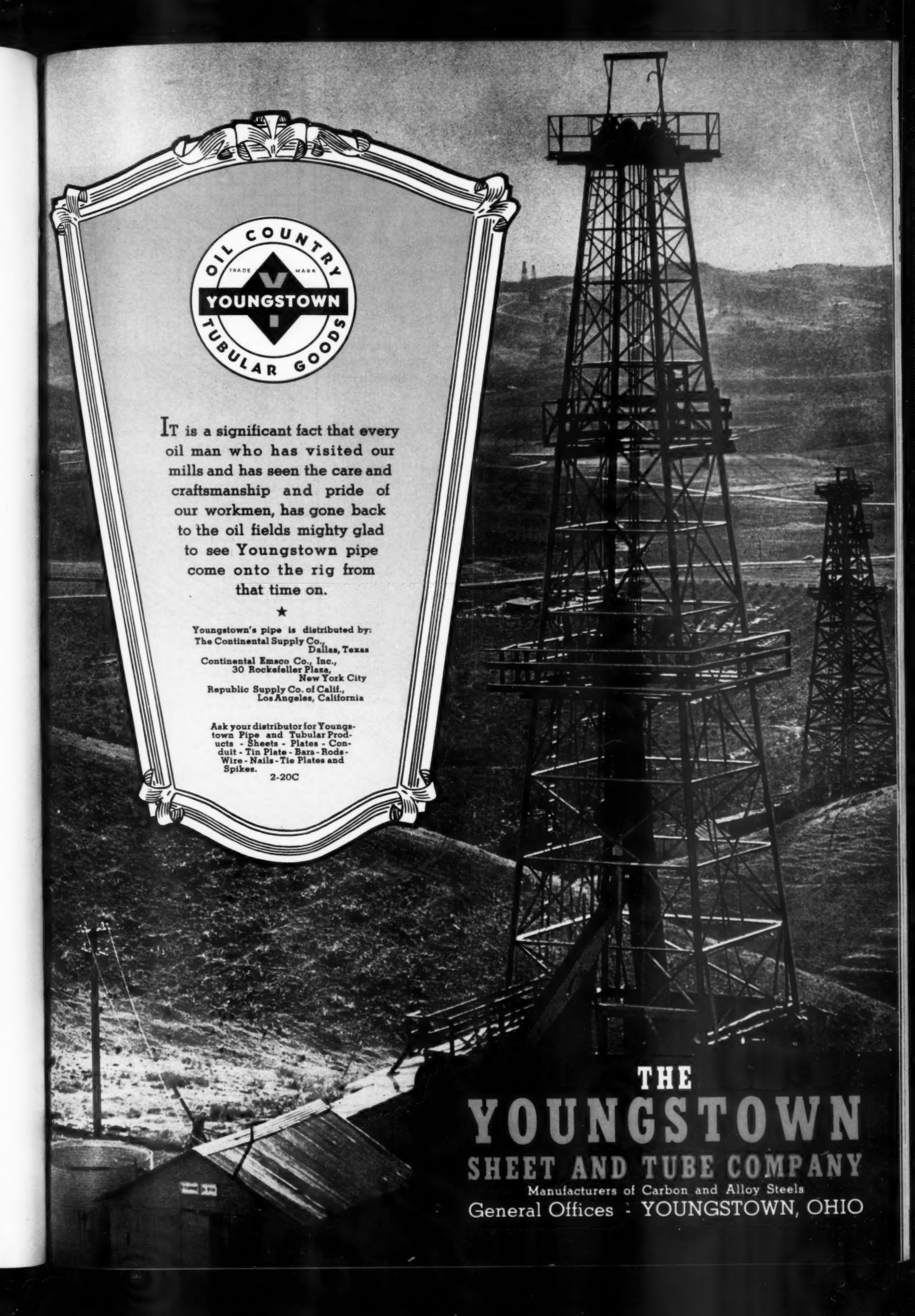
By means of these equations the velocity distribution curve and the resistance curve of the rough pipes with the type of roughness considered, are represented with sufficient accuracy.

Finally, calculated by von Kármán[16] on the basis of his hypothesis of similarity:

$$\frac{U - u}{v^*} = -\frac{1}{x}\left[\log (1 - \sqrt{1 - y/r})\right.$$

[15] *L. Prandtl:* Zur turbulenten Strömung in Rohren and längs Platten. Ergebn. Aerodyn. Versuchsanst. Göttingen, 4. Lief. 1932 S. 18. *J. Nikuradse:* Gesetzmöszigkeiten der turbulenten Stromung in glatten Rohren. VDI-Forsch.-Heft. 356, Berlin, 1932.

[16] *Th. v. Kármán:* Mechanische Ahnlichkeit und Turbulenz. Göttinger Nachr., Math.-Phys. K1. 1930.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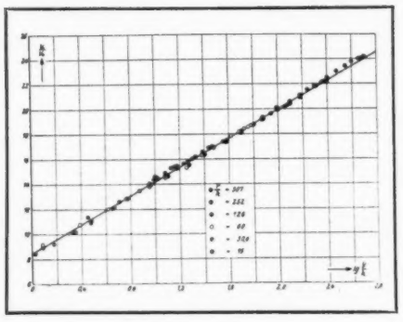
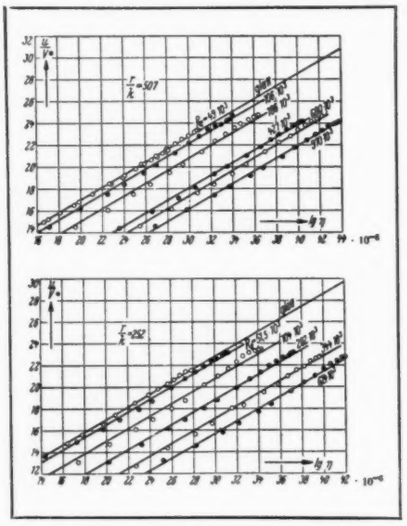


Fig. 11
u/v* depends on log y/k

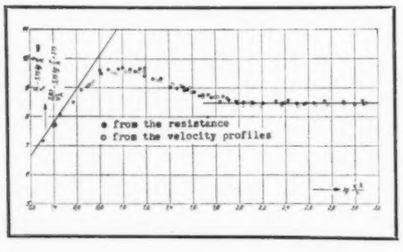


Figs. 12a and 12b

$$+\sqrt{1-y/r}\Big] \ldots\ldots\ldots (22)$$

it may be shown how the velocity distribution agrees with the experiment, in which x is a universal constant, which is determined from the velocity distributions. In Fig. 14, the solid curve almost coincides with the theoretical curve. For very large Reynolds Numbers, where the effect of viscosity is very slight, the velocity distributions in the von Kármán graph do not depend on the nature of the wall and on the Reynolds Number. For such velocity distributions a good agreement is

Fig. 13



obtained with $x = 0.36$ between the experimental and the theoretical curves, up to the proximity of the wall. Hence one may conclude that the graph of flow and the exchange of momentum at a certain wall distance y are independent of the nature of the wall.

To be able to include the velocity distribution measuring points, which are situated near the wall, the magnitude, $\frac{U-u}{v^*}$, is determined from the universal velocity distribution curve, equation (14), as follows: If equation (14) is used for the maximum velocity by inserting $u = U$ and $y = r$, the result is:

$$\frac{U}{v^*} = 5.5 + 5.75 \log \frac{v^* r}{\nu}$$

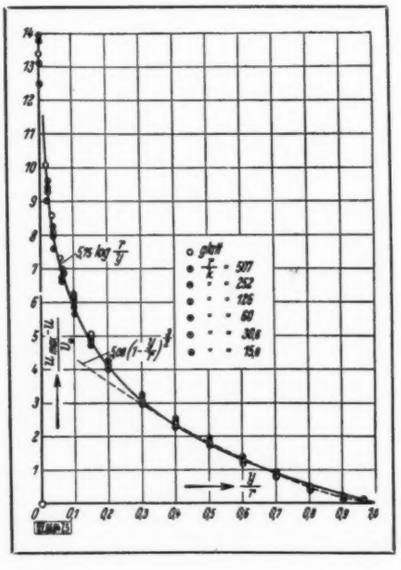
If we subtract equation (14) from this equation, we obtain the relation:

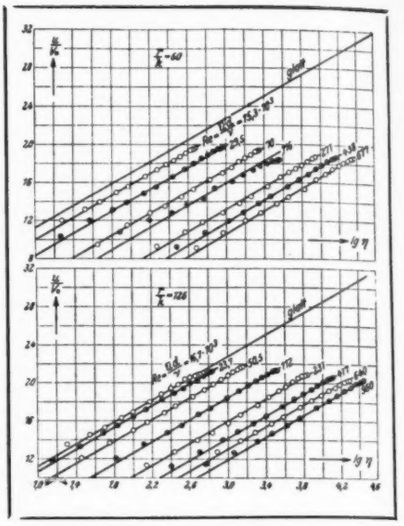
$$\frac{U-u}{v^*} = 5.75 \log \frac{r}{y} \ldots\ldots (23).$$

In contrast to the von Kármán theoretical curve, which represents the measuring points close to the wall, only with a different x, this relation, derived from the data, describes the entire range between the wall and the center of the tube. In this connection, it is interesting to quote for comparison the equation for velocity distribution, developed by Darcy[2] in the year 1855, based on his careful measurements, which, after transcribing in our formula is:

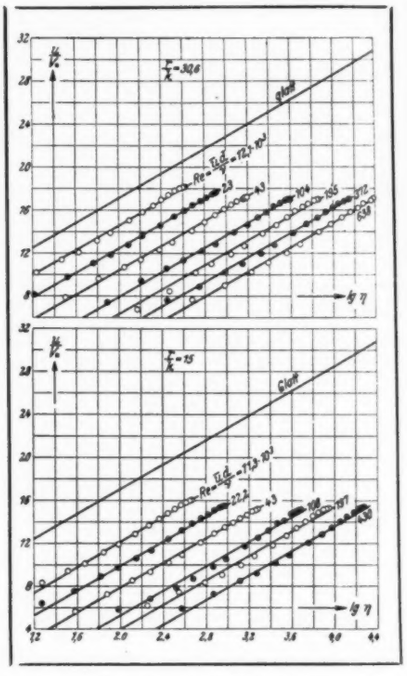
$$\frac{U-u}{v^*} = 5.08\left(1-\frac{y}{r}\right)^{\frac{3}{2}} \ldots (24)$$

Fig. 14





Figs. 12c and 12d

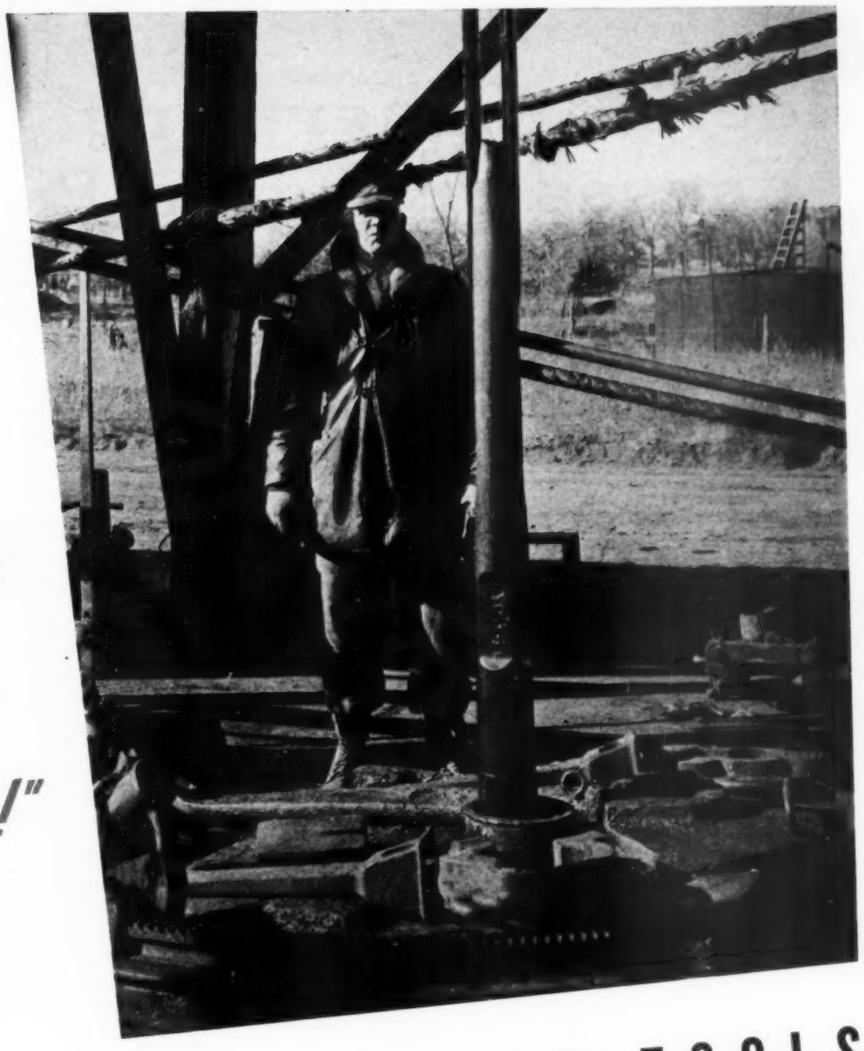


Figs. 12e and 12f

In Fig. 14, equation (23) is represented by a solid curve, and equation (24) is shown by a broken curve. The Darcy curve shows good agreement, except for the points close to the wall, in which $y/r < 0.35$. This incompleteness of the Darcy formula comes from his having chosen $y/r = 0.33$ as the point closest to the wall in his experiments. Up to this point the agreement of equation (24) with the measurements is very good.

Editor's Note: This article will be continued in an early issue.

"Aye! 'Tis the way I'd do it!"



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Electric Generating Plants on Kansas Producing Properties

Drawdown method of taking potentials permits daily allowables to be pumped with 3 to 4 hp. per well

By R. A. AXE
Engineer, Cities Service Oil Company

THE oil production department of the Cities Service Oil Company, during the last year, constructed and placed in operation three small generating plants on the partly developed Rumsey and Hall "B" leases in the Bemis field in Western Kansas. The installation of the plants and the electrification of the leases were made possible by the existing proration regulations that have reduced the horsepower required to produce the wells.

Before the adoption of proration regulations by the State of Kansas, the lowest operating cost had been obtained by installing pumping equipment that would pump all the oil a well was capable of producing. This permitted depleting the wells in the shortest practicable time and prevented drainage of oil to adjoining leases. The first proration orders required that a physical potential be made on each well; under such conditions it was still necessary to install large-capacity pumping equipment that resulted in excessive costs in equipping the wells and in operating the equipment. During the period these initial orders were in effect, 17 wells were drilled on the Rumsey, McCord, and Hall "B" leases. Thirteen wells were equipped with 50-hp. vertical gas engines driving 40-hp. pumping units and four wells were equipped with 20-hp. vertical gas engines driving 22½-hp. pumping units.

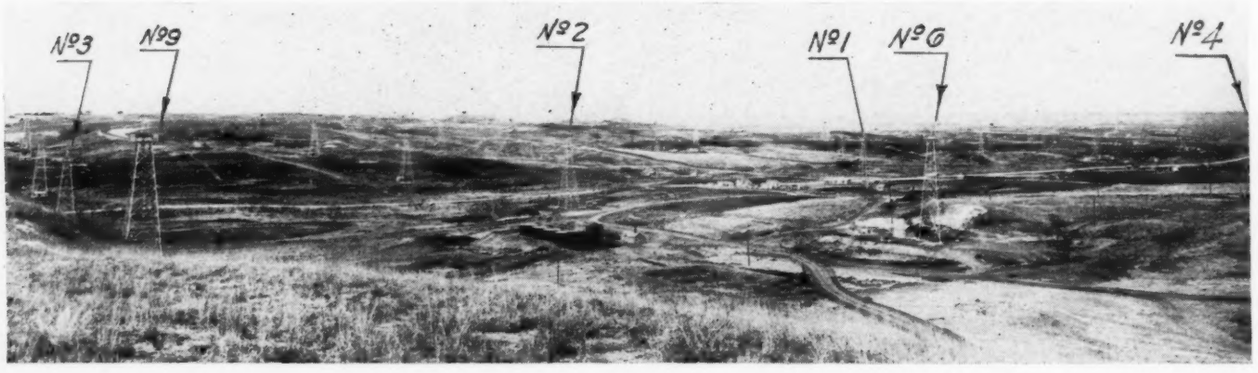
R. A. AXE

obtained his degree in mechanical engineering from Texas A. and M. in 1923—Entered employ of Cities Service Company immediately following graduation—Upon completion of training work was assigned to the Engineering-Construction Department—From 1923 to 1927 was resident engineer in charge of construction of oil and gas pipe line stations—Was transferred to Bartlesville office in 1928 and placed in charge of the design and supervision of this type of work.

When the Kansas Corporation Commission approved the "drawdown method" of taking potentials early in 1939, a study was made to determine the size of pumping units that should be installed in the further development of the leases. The 10-hp. pumping unit driven by a 15-hp. gas engine was selected as a result of this study and equipment of this type was installed on the next five wells drilled on these leases. Units of this size were found to have sufficient capacity, due to the high fluid levels throughout the field, to determine potentials by the new method and to handle the pumping requirements until such time as the total fluid (oil and water) to be lifted exceeds 500 bbl. per day.

Under present operating conditions only 3 to 4 hp. is required to produce the daily allowable per well and unless conditions change materially the horsepower requirement is not expected to increase for many years. In order, therefore, to utilize the gas-engine horsepower already installed on these leases, three 35-kw., 1200 r.p.m., 44-v. electric generators were purchased and installed in the 14 by 14 by 8 engine houses at Rumsey No. 3, Hall "B" No. 6, and Hall "B" No. 10. The buildings were large enough to house the new generators conveniently, and the conversion of the well equipment into generating plants only required the pouring of 2-ft. by 2-ft. generator foun-

Hall "B" Lease—Generating plant is at No. 6



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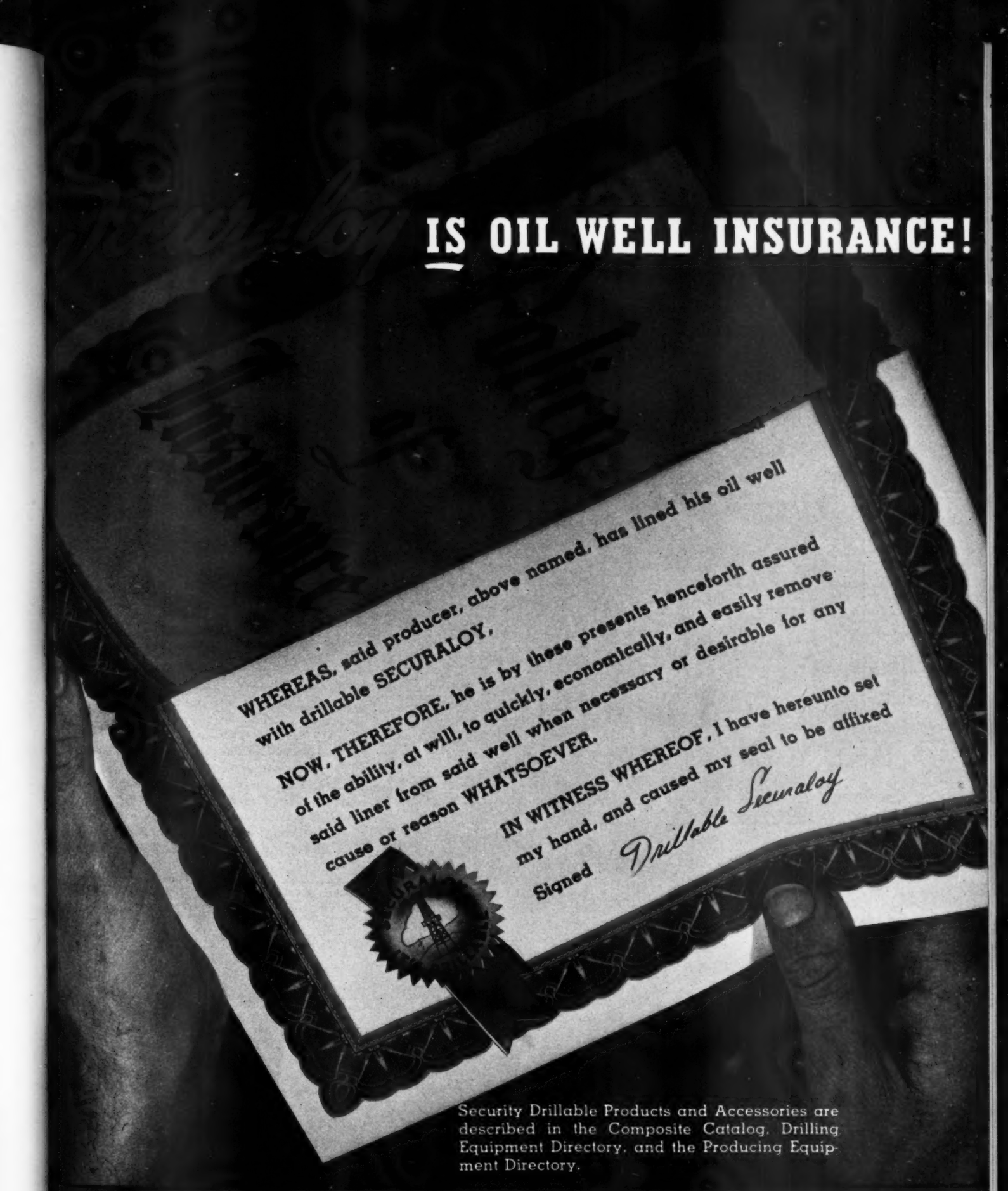
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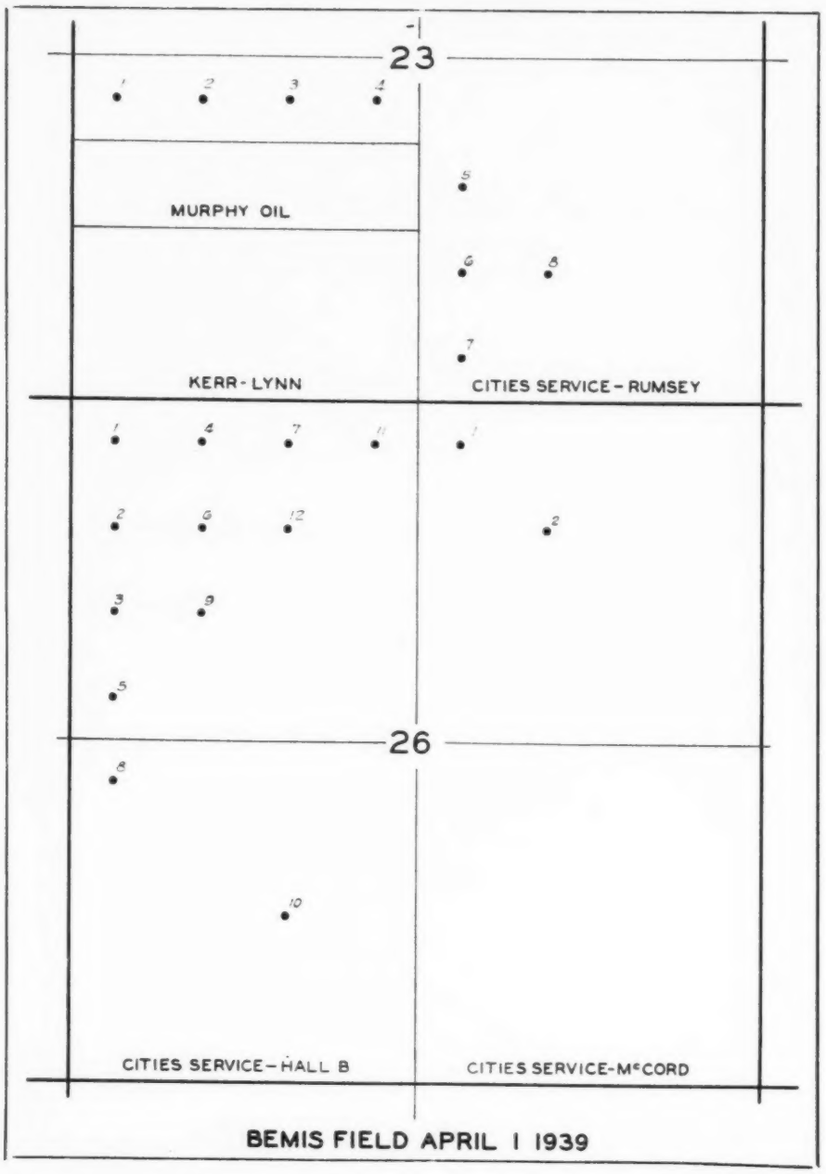


Fig. 1—Leases prior to electrification

dations and the installation of new V-belt drives on the 50-hp. engines at these wells. At the Hall "B" No. 10 plant, a 10-hp. weatherproof gear motor was installed to drive the 40-hp. pumping unit. At the other plants, new 10-hp. pumping units and weatherproof motors were installed on the old unit foundations and the 40-hp. units were reclaimed.

Justification for the installation of the generators and the electrification of the leases was threefold:

(1) The reduction in the first cost of equipping newly drilled wells with electric motors as compared with multi-cylinder gas engines would pay-out the cost of converting the existing equipment to generating plants.

(2) The sale or transfer of one large pumping installation to another lease where it is needed would pay the cost of one generating plant.

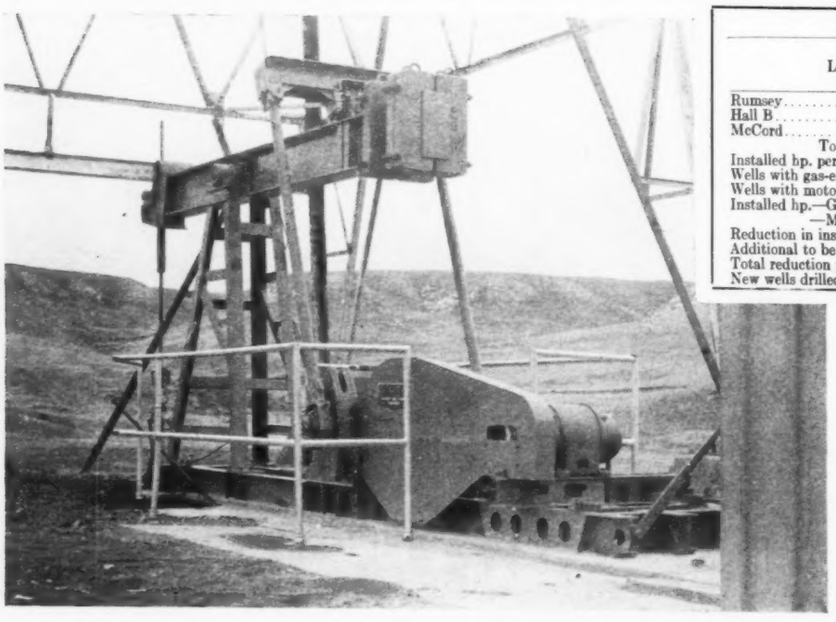
(3) The reductions in operating costs would pay-out the new investment in the generating plants.

Fig. 1 is a plat of these leases before the generating plants were constructed and Fig. 2 shows the new wells that have been drilled, the electric lines that have been built, and the locations of the generating plants. Table 1 has been prepared to show a comparison of the number of wells and installed gas-engine horsepower on the leases prior to the electric installations and the present number of wells and installed gas-engine horsepower.

During the last year ten new wells were drilled and equipped with 10-hp. motor-driven pumping units and 500 gas-engine horsepower was salvaged for use elsewhere by equipping the old wells with new motor-driven units. Only five wells totaling 155 installed gas-engine horsepower are now produced with individual gas engines and this equipment will be replaced as soon

TABLE I — BEMIS FIELD

Leases	Number of wells		Power in equivalent gas engine hp.	
	4-1-39	4-1-40	4-1-39	4-1-40
Rumsey	8	15	240	190
Hall B	12	15	530	100
McCord	2	2	35	15
Total	22	32	805	305
Installed hp. per well			36.6	9.5
Wells with gas-engine drive	22	5	805	155
Wells with motor drive	0	27	0	150
Installed hp.—Gas-engine drive			36.6	31.0
—Motor drive			0	5.6
Reduction in installed hp., 4-1-40				500
Additional to be reclaimed				155
Total reduction possible				655
New wells drilled		10		0



A 10-hp. motor-driven pumping unit installed on old block at Hall "B" No. 6

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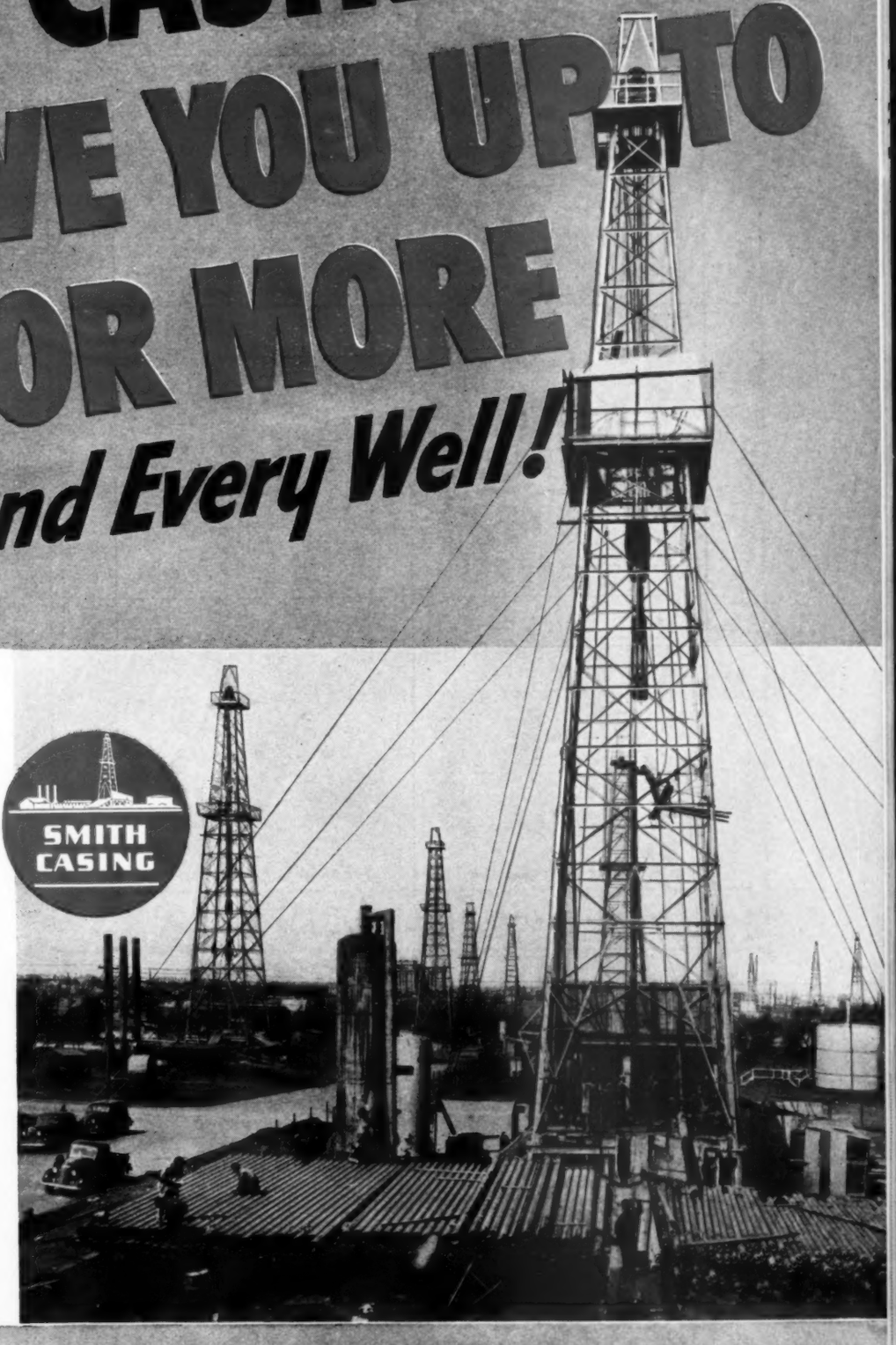

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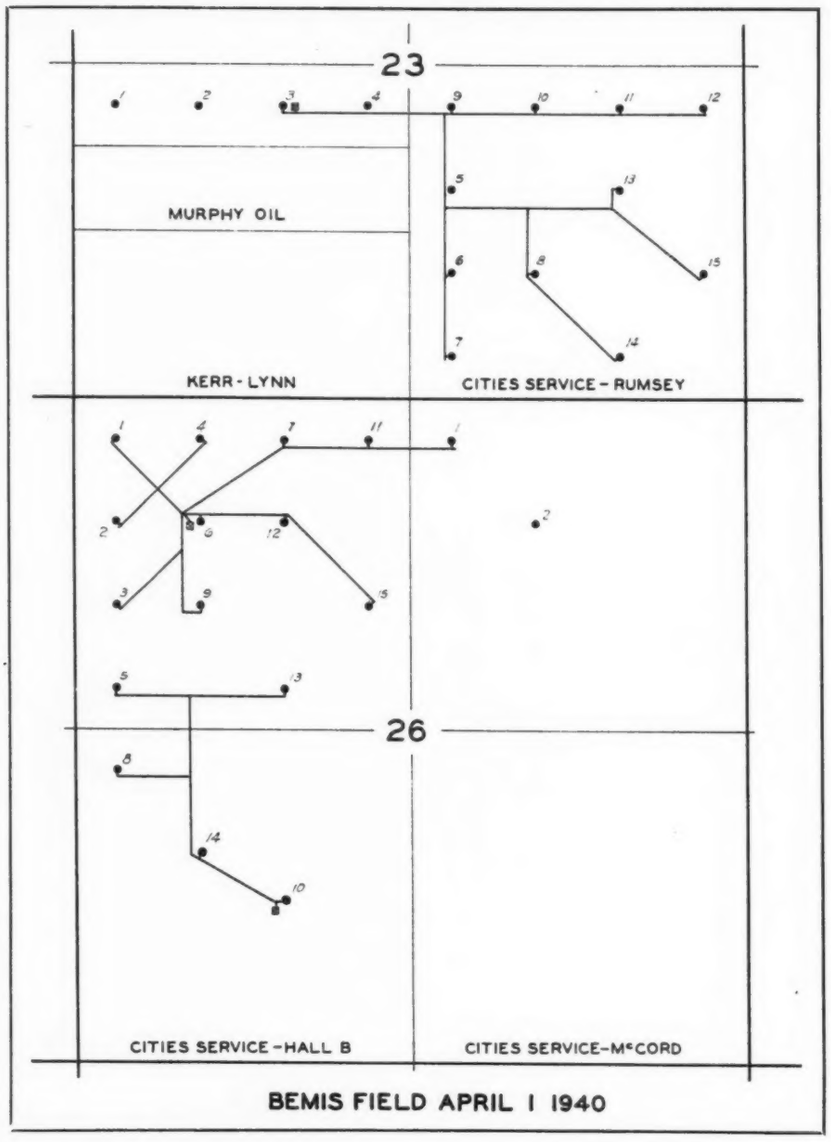


Fig. 2—Leases after electrification

as the equipment is either sold or can be transferred to other properties where it is needed. The three engines with 150 installed horsepower that were originally required to take physical potentials and produce only three wells are now generating electric power for the 26 wells that are equipped with 10-hp. motor-driven pumping units and 1 well equipped with a 40-hp. unit driven by a 10-hp. gear motor.

The cost of converting the well equipment into a generating plant averaged $1700 or a total of $5100 for the three plants. The power lines were built with No. 1 and No. 4 wire on 30-ft. treated pine poles and the cost averaged 20 cents per linear ft. of line.

A policy has been followed of not reclaiming the large equipment until it was either sold or could be used on other properties and therefore all costs are not complete. It is of interest, however, to see what has happened to the old equipment.

1. Five of the 50-hp. engines have been transferred to other properties where they are used daily in driving equipment in water-flooding, gas-repressuring, gasoline, and gas compressor plants.

2. Seven 40-hp. pumping units were sold for an amount sufficient to pay for 14 of the 10-hp. pumping units installed on the leases.

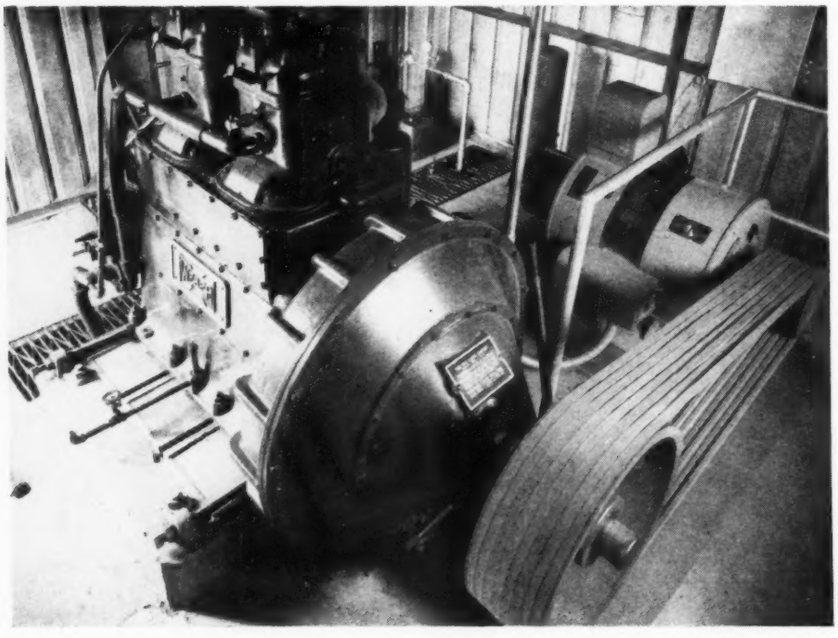
3. Three 50-hp. engines and three 40-hp. pumping units, buildings, water tanks, and air-starting equipment were transferred to large fluid-producing wells in New Mexico. The purchase of new equipment for the latter wells would have cost $15,300.

4. Two 20-hp. engines with the 22½-hp. pumping units were transferred to a partnership-operated lease.

5. Four 15-hp. multi-cylinder gas engines were replaced with electric motors and the engines are now producing wells on other leases.

On the 10 new wells that have been equipped with electric motor-driven pumping units, there is an estimated saving of $2500 or $250 per well as compared with equipping these wells with multi-cylinder gas engines.

A material reduction will be made in the operating costs of these leases but the project has not been in operation long enough to obtain a true picture of these costs.



Hall "B" No. 6 generating plant

Chemistry of Combustion

Calculation of oxygen needed and other data required in combustion problems involves only simple knowledge of atomic and molecular weights

By

E. R. SPENCER

Assistant Chief Engineer, The Texas-Empire Pipe Line Company

COMBUSTION is the chemical union of some basic element with oxygen. The basic elements are those substances that cannot be broken down to some other form; examples are carbon, hydrogen, iron, gold, silver, oxygen, and nitrogen. All materials are made up either of these elements alone or of combinations of such elements, known as compounds. Compounds can be broken down to their elements in various ways; for instance by heating water (H_2O) to approximately 2200°F., separate atoms of hydrogen and oxygen may be obtained. An atom is the smallest unit quantity of an element that is capable of entering into chemical combination. A molecule is the smallest unit quantity of matter that can exist by itself and retain all the properties of the original substance. Many of the elements exist in double form; oxygen is an example of this type. Two atoms unite to form one molecule of oxygen gas, which is represented thus: O_2. The element does not necessarily stay in this form; for example, when two atoms (or one molecule) of hydrogen, H_2, unite with oxygen to form water, the oxygen, "O_2", breaks up and only "O", one atom, joins the H_2. Thus, the actual formation of water is accomplished as follows: Two molecules of hydrogen gas ($2H_2$) unite with one molecule (O_2) of oxygen to form two molecules of the water compound and is written thus:

$$2H_2 + O_2 = 2H_2O.$$

The principal element in coal and petroleum is carbon, "C". This element generally exists alone, i.e., in the atomic state as "C", and not as "C_2", the molecular form. We find then the equation:

$$C + O_2 = CO_2.$$

This is carbon dioxide, which is the normal product of the combustion of coal or fuel oil. If insufficient oxygen is supplied, it will break up and only one atom will unite with each carbon atom forming carbon monoxide, thus:

$$2C + O_2 = 2CO.$$

E. R. SPENCER

has been with The Texas Pipe Line Company and affiliated companies since June, 1929—Began work as maintenance engineer for The Texas-Empire Pipe Line Company, Tulsa, Oklahoma, where his first duties were to supervise the installation of approximately 30,000 hp. in Diesel-driven pumping units, after which he worked out a systematized maintenance program for the equipment—In 1933 he was transferred to The Texas Pipe Line Company, Houston, Texas, to develop for that company a maintenance system similar to the one installed for Texas-Empire — On January 1, 1934, the Maintenance Department of the company was absorbed by the Engineering Department and he was made assistant chief engineer in charge of mechanical work—Late in 1936 he returned to Tulsa in charge of Texas-Empire's engineering offices at that place, which were under the remote supervision of the chief engineer who maintained his headquarters in Houston—Spencer received a bachelor's degree in mechanical engineering from State College of Washington in 1926—He taught at Texas A. and M. College, 1927-29, and also did work on his master's degree—This month (June) he was awarded a professional degree in mechanical engineering by State College of Washington — Is a member of the American Society of Mechanical Engineers.

It is evident that the above is purely an atomic combination without reference to weight or volume. To provide a quantitative comparison for chemical elements, the relative atomic weights have been determined. The weights of the atoms of various elements are compared to the weight of one atom of hydrogen as a standard. For instance, the atomic weight of oxygen is 16. This means that one atom of oxygen weighs 16 times as much as an atom of hydrogen. Similarly, the atomic weight of carbon is 12 and it therefore weighs 12 times as much as an atom of hydrogen. This same weight system holds true in compounds but is then, of course, called the molecular and not the atomic weight. The molecular weight of a compound is the sum of the several atomic weights contained in it. Thus, the molecular weight of CO (carbon monoxide) is 12 plus 16, or 28. Keeping the relation of atomic and molecular weights in mind, it is relatively simple to compute the weight of oxygen required to burn a given weight of carbon or hydrogen completely:

$$C + O = CO_2$$
$$12 + 32 = 44.$$

These numbers of course refer to the atomic and molecular weights. It then becomes evident that for a given weight of carbon to burn to carbon dioxide, 32/12 or 2.67 times oxygen (by weight) is required. Thus, when one pound of carbon is burned to CO_2, 2.67 lb. of oxygen is required. This will produce 3.67 lb. of CO_2:

$$C + O_2 = CO_2$$
$$1 \text{ lb.} + 2.67 \text{ lb.} = 3.67 \text{ lb.}$$

By similar reasoning, the following equations are true:

$$2C + O_2 = 2\,CO$$
$$24 + 32 = 56$$
$$1 \text{ lb. } C + 32/24 \text{ lb. } O_2 = 2.33 \text{ lb. } CO$$
$$2H_2 + O_2 = 2H_2O$$
$$4 + 32 = 36$$
$$1 \text{ lb. } H_2 + 32/4 \text{ lb. } O_2 = 9 \text{ lb. } H_2O$$

Internal-combustion engine fuels, whether gaseous or liquid, are com-

prised of compounds known as hydrocarbons. The hydrocarbons are compounds produced by the union of hydrogen and carbon atoms. These compounds vary from CH_4 (methane gas) to $C_{30}H_{62}$, or solid paraffin. The above-named compounds represent the extremely light and heavy hydrocarbons, respectively. The experiments of Blair, Wheeler, and Bone prove quite conclusively that during combustion, the heavier hydrocarbons undergo a cracking process; thus, breaking down to the simpler forms with which we will deal in this article.

If methane gas, CH_4, is burned, the products of combination will be both CO_2 and H_2O. Thus:

$$CH_4 + 2O_2 = CO_2 + 2H_2O.$$

By rewriting this equation and applying the above reasoning, the quantity of air required to burn 1 lb. of CH_4 can be calculated:

$$CH_4 + 2O_2 = CO_2 + 2H_2O$$
$$16 + 64 = 44 + 36$$
1 lb. $CH_2 + 64/16$ lb. $O_2 =$ 5 lb. of CO_2 and H_2O
or $44/80 \times 5 = 2.75$ lb. of CO_2
$36/80 \times 5 = 2.25$ lb. of H_2O

Similarly the equation can be written for solid paraffin, an extremely heavy hydrocarbon, and the oxygen required for its combustion may be calculated:

$$2C_{30}H_{62} + 91\ O_2 = 60CO_2 + 60\ CO_2 + 62\ H_2O$$
$$844 + 2912 = 2640 + 1116$$
1 lb. $C_{30}H_{62} + 2912/844$ lb. O_2 = 4.45 lb. CO_2 and H_2O
$2640/3756 \times 4.45 = 3.13$ lb. CO_2
$1116/3756 \times 4.45 = 1.32$ lb. H_2O

The above two examples illustrate the simplicity of calculating the oxygen required for combustion of any hydrocarbon. The extreme importance of the presence of oxygen in sufficient quantities is indicated in the above equations.

The oxygen supplied to the internal-combustion engine comes usually from the air at atmospheric conditions. Air contains (by weight) 23 percent oxygen and 77 percent nitrogen. Nitrogen is an inert gas and does not enter directly into the problem of combustion. It is evident then that 4.35 lb. of air must be supplied to obtain 1 lb. of oxygen. When 1 lb. of carbon is to be burned to CO_2, therefore, it will be necessary to supply 4.35×2.67,* or 11.6 lb. air.

The same result may be obtained by dividing the oxygen required for combustion. Thus:

$2.67/0.23 = 11.6$ lb. air.

Element or Compound	*O_2 required per lb. of substance*	*Air required in lb. per lb. of fuel*	*Air required,* cu. ft. per lb. of fuel*
H_2 to H_2O	8	34.6	428.7
C to CO	1.33	5.8	71.9
C to CO_2	2.67	11.6	143.7
CH_4 to CO_2 and H_2O	4.0	17.4	215.6
$C_{30}H_{62}$ to CO_2 and H_2O	3.45	15.0	185.9
(Kerosine) $C_{12}H_{26}$ to CO_2 and H_2O	3.47	15.1	187.1

*Note: above air volumes are at atmospheric conditions.

After combustion is completed, the next question vitally affecting Diesel engine operation is that of the heat liberated during the process of chemical reaction. In fact, the sole duty of an engine is to transform this heat energy to mechanical energy.

When 1 lb. of carbon is burned to carbon dioxide (CO_2), 14,600 B.t.u. of heat is liberated. If instead of burning to CO_2, the process is incomplete and the product is CO, the heat liberated is 4,380 B.t.u., leaving 14,600 minus 4,380 or 10,220 in the CO formed. In the preceding discussion, it was stated that 1 lb. of carbon burned to CO formed 2.33 lb. of this product. When carbon monoxide is exhausted from an engine, therefore, it contains 10,220/2.33 or 4,386 B.t.u. per lb. This heat is, of course, lost and the high cost of poor combustion is therefore evident. Hydrogen also liberates heat when combining with oxygen. One pound of hydrogen combined with 8 lb. of oxygen liberates 62,100 B.t.u. This value is known as the higher or gross heat content. It is impossible to recover the higher heat content of hydrogen because the water formed as a by-product of combustion carries an appreciable amount of heat with it in the exhaust. In problems of design, the lower heat value of 52,230 B.t.u. is used.

The weight of carbon and hydrogen in 1 lb. of kerosine, $C_{12}H_{26}$, is calculated as follows: Divide the molecular weight of each element by that of the compound.

$144/170 = 0.847$ lb. C;
$26/170 = 0.153$ lb. H_2.

The lower heat value then will be:

$0.847 \times 14{,}600 + 0.153 \times 52{,}240 = 20{,}359$ B.t.u. per lb. of $C_{12}H_{26}$.

P 425.218.411

New Device for Testing Oil-Well Drilling Muds

THE Eykometer, a new device for measurement of the yield point of clay suspensions and oil-well drilling muds, is described in a report published by the U. S. Bureau of Mines. The report was prepared by A. George Stern, associate chemical engineer, Bureau of Mines, the inventor of the device.

In the examination of bentonitic clay suspensions used for oil-well drilling fluids, it is important to have comparative tests for evaluating them. A satisfactory clay for these and other purposes should have the property of forming what is commonly called a "gel," but the measurement of this property has been a real problem. To date the solution has not been satisfactory, and some of the difficulties are considered in this discussion.

Proposals have been made to measure this "gel" property by allowing a cylinder, sheet, or other shaped metal to sink through the mud and observe the depth to which it sinks. This and other methods have been tried, but shortcomings have prevented their wide adoption. Use of the Stormer viscometer to determine the maximum load that can be placed on the weight pan without causing motion of the rotor has been recommended, and it is the only device that seems to be widely used; however, reproducibility of observations is poor. When results obtained by this method of measurement are compared with those of the Eykometer they indicate that the new instrument may have some utility.

The mud to be examined is placed in a rubber balloon fastened to a transparent tube of special construction. The hydrostatic pressure that must be impressed to distort the balloon and cause initial motion of the mud in the tube is recorded as the Eykometer pressure for yield. A comparison of Eykometer yield pressures with Stormer gel strengths has been made and a smooth curve relation was found to result. Several determinations with the Eykometer to illustrate its applications were made, including the effect of mud concentration and time of quiescent set.

Copies of Report of Investigations 3495, "The Eykometer. A New Device for Measurement of the Yield Point of Clay Suspensions and Oil-Well Drilling Muds," may be obtained from the U. S. Bureau of Mines, Washington, D. C.

Running Tour
WITH MEN IN THE INDUSTRY

JOHN KELLY, petroleum engineer of Hobbs, New Mexico, has been appointed engineer for the Lea County Operators Committee.

ROBERT M. HUTCHISON, chief engineer of the Houston Natural Gas Company, Houston, Texas, was recently elected president of the Houston Engineers Club.

F. N. BOSCO, petroleum engineer, returned to the United States recently from Brazil. He expects to make his headquarters in Denver, Colorado, for the time being.

SAMI N. NASR, geologist for the Iraq Petroleum Company, Ltd., has been transferred from Iraq to Haifa, Palestine.

J. A. BOLLE has resigned from Humble Oil and Refining Company to accept a position with Nederlandsche Koloniale Petroleum Mij. and has left Houston, Texas, for Palembang, Sumatra.

JOSEPH CHALMERS, exploitation engineer for De Bataafsche Petroleum Mij., has returned to the United States from The Hague and is now making his headquarters at St. Louis, Missouri.

L. E. BROCK, JR., junior petroleum engineer, Stanolind Oil and Gas Company, has been moved from Pampa, Texas, to division headquarters at Fort Worth. **W. E. POWERS** has taken over his duties at Pampa.

WILLIAM GRANTHAM has been appointed superintendent of the General Petroleum Corporation's Vernon, California, pipe-line station. He has been a dispatcher in the company's main office at Los Angeles.

BOB GUTRU, geologist with the Cities Service Oil Company, Gulf Coast Division, is now stationed at Wichita, Kansas.

B. N. MOORE, geological department, Atlantic Refining Company, New York City, has been assigned to Port-au-Prince, Haiti.

JAMES PARKER is manager of the Arrow Drilling Company's new division office recently established at 804 Anderson Building, Fort Worth, Texas. He will be in charge of operations in the North Texas area.

WILLIAM L. RUSSELL, geologist with the Michigan Devonian Petroleum Company, has been transferred from Macomb, Illinois, to Tulsa, Oklahoma.

L. A. BOYD, who has been superintendent of the Gas and Oil Products Company's refinery at Turner Valley, Alberta, Canada, has resigned to move to Tulsa, Oklahoma. **W. NEILSON,** who has been assistant superintendent of the plant, becomes superintendent.

J. C. CHATFIELD, for the last 18 years a writer for *National Petroleum News,* resigned recently to join the staff of Indian Territory Illuminating Oil Company. He will make his headquarters at Bartlesville, Oklahoma.

Chatfield is to conduct studies of economic conditions in the oil industry for the I.T.I.O. management and engage in the sale of raw products.

At the time he resigned from the *National Petroleum News* staff Chatfield was managing editor of the refining technology edition. Previously he had served in the advertising department and as market reporter in the Mid-Continent area.

FRANK BUTTRAM, president of the Independent Petroleum Association of America, has appointed two members to the association's Committee on Refining and Marketing Practices to provide representation for the Pacific Coast and Pennsylvania grade areas. They are **JAMES H. LEWIS,** president of the Sunset Oil Company, Los Angeles, California, and **T. O. GRISELL,** vice-president of the Kendall Refining Company, Bradford, Pennsylvania. The committee, which served in 1939, had previously been reappointed. It consists of **CHARLES F. ROESER,** Fort Worth, Texas, as chairman; **JOHN M. LOVEJOY,** president of the Seaboard Oil Corporation, New York City; **B. L. MAJEWSKI,** Deep Rock Oil Corporation, Chicago; **PAUL G. BLAZER,** president of the Ashland Oil and Refining Company, Ashland, Kentucky, and **WALTER A. JONES,** Pittsburgh, Pennsylvania.

WILLIAM TAGGART has been made manager of tube sales by The Timken Roller Bearing Company. Taggart has been associated with the Steel and Tube Division of The Timken Roller Bearing Company since June, 1928. Prior to that time he was employed by Republic Steel Corporation.

A. I. RICHARDSON has been appointed manager of Allis-Chalmers Manufacturing Company's district office at Dallas, Texas, according to a recent announcement by **WALTER GEIST,** vice-president of the company. He was previously at the company's district office in Charlotte,

A. I. RICHARDSON

North Carolina. Richardson is a native of Texas, attended the public schools of McKinney, and graduated in mechanical engineering from Texas A. & M. College. He entered the employ of Allis-Chalmers in 1925, spending two years in their shops prior to preparing for sales engineering work. Since then he has had a wide experience in the company's district offices at Atlanta, Georgia, Chattanooga, Tennessee, and Charlotte, North Carolina.

THESE TOOLS Help Cut Production Costs

1

2

1. BJ SHORTYPE C TUBING CATCHERS provide low-cost protection for tubing strings of average length. They are sturdy in design and construction—simple and positive in operation. Can be equipped with a BJ Anchor when desired to prevent tubing breathing.

2. BJ SURESTOP TUBING CATCHERS are safe for the longest, heaviest tubing strings, and insure against the hazards of a dropped or parted string at all times when the tubing is suspended while pumping and when it is being run in or pulled out of the well. When set at any depth with the BJ Anchor they prevent coupling and casing wear by eliminating "tubing breathing"—vertical movement of the tubing.

3. BJ "50" TUBING HOOKS are equipped with the famous "Locking Arm" which automatically closes when any load is imposed on the hook, thus forming a strong C-link and preventing the elevator links from "jumping" the hook. The "50" is for loads up to 50 tons; the "75" is for 75-ton loads.

4. BJ "30" TUBING HOOK—This strong ball bearing tubing hook is designed for use in short derricks where overhead clearance is limited. The BJ Locking Arm converts the hook into a closed C-link and adds to its load-carrying capacity.

5. BJ "15" ROD HOOKS are made for handling strings of sucker rods weighing up to 15 tons. The natural hand grip at the center of balance safely speeds up work by providing an easy method of opening and closing the BJ Locking Arm. The smaller "10" Rod Hook is recommended for 10-ton loads.

6. The BJ "20" ROD HOOK has an enclosed, protected relief spring which reduces hazard of burring threads and increases handling speed. The conveniently located hand grip provides perfect balance while opening or closing the BJ Locking Arm.

3

4

5

6

LOOK IN YOUR COMPOSITE CATALOG
BJ Section Begins on Page 463

BYRON JACKSON CO. • *Los Angeles, Houston, New York*

BJ Production TOOLS

H. R. CUTLIP has been made district manager by Union Wire Rope Corporation, Kansas City, Missouri, of Texas and Louisiana, with headquarters in Houston, Texas. Cutlip was formerly district manager of the Fort Worth branch.

J. WILFORD (BILL) CONNOLLY is now Griscom-Russell Company sales engineer, at 310 Thompson Building, Tulsa, Oklahoma. He was formerly with the New York office of the company.

J. N. YOUMANS, assistant superintendent of the Coffeyville, Kansas, refinery of the Sinclair Refining Company, has been transferred to Wellsville, New York, and will be superintendent of the company's refinery at that place.

H. I. JOHNSON, production superintendent for the Bistate Oil Company has transferred his headquarters from Oilmont to Ferdig, Montana.

E. H. ANCHORS, formerly branch manager for the Air Reduction Sales Company at Atlanta, Georgia, has been appointed manager of the Oklahoma City district. Anchors began his career

E. H. ANCHORS

15 years ago with the Commercial Acetylene Supply Company. He was southern manager of this company when it was acquired by Air Reduction. Since that time he has served continuously as branch manager at Atlanta.

V. D. MARTIN, Richmond Petroleum Company, Bogota, Colombia, is taking his vacation in the United States.

RALPH E. FAIR, president of Ralph E. Fair, Inc., has moved his offices from Dallas to San Antonio, Texas.

TED JUDD, now employed by the Latex Construction Company, Houston, Texas, recently returned from Hungary where he was superintendent of construction for a crude oil pipe line laid near Budapest.

ROY K. EGGELSTON, superintendent at Three Rivers, Texas, for the Three Rivers Refining Company, has been transferred to Elgin, Texas.

E. J. GALT, independent operator, has moved his offices from Ardmore, Oklahoma, to San Antonio, Texas.

HOMER C. MOORE, geologist, has been moved by The Texas Company from West Frankfort, Illinois, to Cadiz, Ohio.

C. K. BRYCE has been elected vice-president of Oxweld Acetylene Company, a unit of Union Carbide and Carbon Corporation, New York. Bryce was formerly manager of factories.

C. B. PETERS, JR., and **SAM W. WELLS,** independent operators, have formed the Norbia Oil Company with headquarters at Corpus Christi, Texas.

HENRY LINAM, president of the Standard Oil Company of Venezuela, and **A. T. PROUDFIT,** manager of operations in eastern Venezuela, recently attended the annual conference of the executive staff of the Standard Oil Company of New Jersey and its subsidiaries at Seaview, New Jersey. They have now returned to South America.

COLIN REITH, petroleum engineer for the Bahrein Petroleum Company, is in California on a combined vacation and business trip.

GEORGE A. FOSTER, formerly drilling supervisor for Kern Trinidad Oilfields, Ltd., Trinidad, has returned to the United States with his family and will settle in the Mid-Continent area.

ROBERTO PARDO BECERRA, assistant secretary and treasurer of the Pantepec Oil Company of Venezuela, has returned to Caracas, Venezuela, after spending some time in the United States.

E. R. SPENCER, assistant chief engineer of The Texas-Empire Pipe Line Company, Tulsa, Oklahoma, on June 3 was awarded a professional degree in engineering by State College of Washington. The degree was given in recognition of outstanding work in the internal-combustion engine field.

V. C. MALEY, geologist for the Humble Oil and Refining Company, has been transferred from Midland, Texas, to Hattiesburg, Mississippi. He will be in charge of geological operations in Mississippi, Alabama, and Florida.

GEORGE BRUNDRETT, engineer, has been transferred by the Fain-McGaha Oil Corporation from Stamford to Wichita Falls, Texas.

A. C. CALVERT, superintendent at Skiatook, Oklahoma, for Barnsdall Oil Company, has been transferred to Galena, Kansas.

DR. MALVIN G. HOFFMAN has resigned as chief geologist for the Midco Oil Corporation, Tulsa, Oklahoma, to engage in consulting work. His address is 1321 South Quaker Street, Tulsa.

W. E. KENNETT, geologist, has been transferred by the Superior Oil Company from Coalinga to Girard, California.

J. H. BAXTER, engineer for the Red Bush Producing Company, who has been stationed at Ashland, Kentucky, is now making his headquarters at Bartlesville, Oklahoma.

MAX LYON, engineer, Carter Oil Company, now has his headquarters at La Junta, Colorado. He formerly was at St. Joseph, Missouri.

W. H. COURTIER has been appointed assistant chief geophysicist for the Phillips Petroleum Company and will make his headquarters at Bartlesville, Oklahoma.

JOHN DOMERCO, petroleum engineer, California Arabian Standard Oil Company, is spending his leave in the United States.

T. L. DONOVAN, who has been with the Caracas Petroleum Company, has transferred his affiliation to The Texas Company, with which organization he is an engineer.

J. A. LYONS has been named chief petroleum engineer for the Texas Railroad Commission in the Gulf Coast district to succeed Heath Renfro, who has been transferred to Corpus Christi, Texas.

E. N. WILSON, who has been superintendent at Oklahoma City, Oklahoma, for the Magnolia Petroleum Company, has been transferred to Dallas, Texas. **A. H. PROCTOR,** superintendent at Stonewall, Oklahoma, has been moved to Oklahoma City to succeed him there.

LAUGH WITH BARNEY

Mrs. Jones: Why, my dear, I haven't seen you for ages.

Mrs. Smith: Oh, I've been so busy with one thing and another—I've just had my teeth taken out, and the gas stove put in.

* * *

Foreman (on a government housing job, testing the wall of a new house): I'm speaking quietly, Bill. Can you hear me?

Bill (one the other side): Hear you? I can see you in three places.

* * *

A man was smashed up in a railroad accident. The family received a wire saying, "Mr. Hess in railroad wreck. Both legs, both arms, back and neck broken, and skull fractured." A few hours later a second dispatch arrived, "Not so bad as at first reported. One arm not broken."

* * *

The girl about to travel alone was warned about talking to strange men. At the station the conductor asked:

"Where are you going?"

"To Detroit," she answered, so he put her on the Detroit train.

As the train pulled out she looked out and said: "Ha, ha! I fooled him that time. I'm going to Chicago."

* * *

Old maids are born and not made.

* * *

A hunter was proudly showing off his collection of trophies to a group of visitors. He was rapturously explaining how he acquired the various exhibits. "See that elephant?" he waxed eloquently. "I shot it in my pajamas."

"My gosh," murmured the surprised young woman. "How did it get there?"

* * *

Doctor: Have you told Mr. Brown that he's the father of twins?

Nurse: Not yet. He's shaving.

* * *

Uncle Ezry had been very much occupied all by himself over in a corner near the fireplace. He was working industriously with a stub of pencil and a piece of paper. Suddenly he looked up happily.

"Doggone," he exclaimed, "If I ain't learned to write!"

Maw got up and looked over the scrawled lines across the paper.

"What do it say?" she asked.

"I don't know," replied Uncle Ezry, puzzled. "I ain't learned to read yet."

Mrs. Newrich: Hurry, John, hurry. The baby just swallowed a quarter.

Mr. Newrich: Well, quit making such a fuss over it. We can afford it.

* * *

"Daughter," said the father, "is that young man serious in his intentions?"

"Guess he must be, dad," she replied. "He's asked me how much I make and what kind of meals we have and how you and mother are to live with."

* * *

Sign Language

Letter from College Student: Dear Dad—Gue$$ what I need mo$t of all. That'$ right. $end it along? Be$t wihe. Your $on.

Letter from Dad to Son: Dear NOrman—NOthing ever happens here. We kNOw you like your school. Write us aNOther letter aNOn. ArNOld was asking about you Monday. NOw we have to say good-by. The GoverNOr.

* * *

Ain't It the Truth?

On clothes she spends her legal tender;
Because this truth she's found—
A dress can make a girl look slender,
And a hundred men look 'round.

* * *

Television will be a wonderful thing, but it will never replace the old fashioned keyhole.

* * *

Tourists are people who travel 2,000 miles to get kodak pictures of themselves standing by the car.

* * *

"Boy, is my girl mad at me!"

"What's the matter?"

"I told her that her bustle was slipping."

"Why, that shouldn't have made her mad."

"Yeah, but she didn't have one on."

* * *

Boarder: I wish I had come here a week earlier.

Landlady (beaming): It's very nice of you to say so, and flattering to our service.

Boarder: Oh, not at all—I would rather have eaten this egg then than now.

* * *

Sally: So Old Gotrocks' check bounced back?

Mary: Yeah, it was marked "insufficient fun."

The man from the city went to the store at the Missouri crossroads and bought a couple of nightshirts. When he had completed his purchase and left the store, a long, lanky backwoodsman asked the merchant:

"What was them things that feller got?"

"Nightshirts," replied the merchant. "How about selling you some?"

"Not me. I don't get around much at night."

* * *

When an American young man tells an American young lady that she looks like a million dollars, the young lady is thrilled from her permanent wave to her manicured toe-nails. But imagine a young English blade telling his English young lady that she looks like a million pounds!

* * *

Historians tell us that women used cosmetics in the Middle Ages. For that matter, women in the middle ages still use them.

* * *

Removing his shoes, he climbed the stairs, opened the door of the room, entered, and closed it after him without being detected.

Just as he was about to get into bed, his wife, half aroused from slumber, turned and sleepily said, "Is that you Fido?"

The husband, relating the rest of the story said: "For once in my life I had real presence of mind. I licked her hand."

* * *

Once upon a time there was a young couple about to get married. She was concentrating on her trousseau and he was concentrating on her torso and that's why her trousseau got torso.

* * *

A beggar held out two hats to a passerby. "Mister," he said, "will ye gimme a nickel for a cup of coffee?"

"Sure," replied the passerby, "but what's the idea of the two hats?"

"Well," said the beggar, "business was so good that I had to open a branch."

* * *

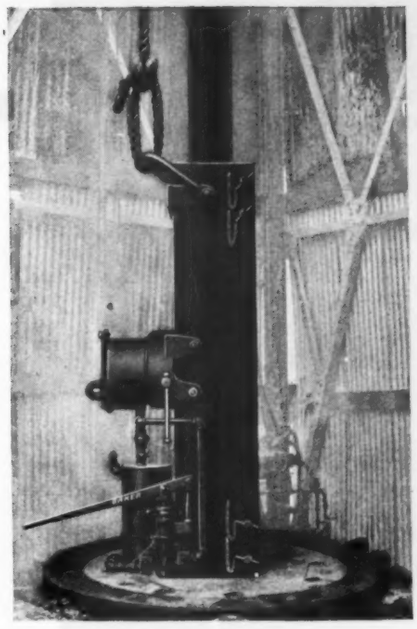
The meanest guy in the world is the restaurant owner who pinches waitress' tips.

* * *

Marriage is like a baseball game—while one man is out, another is getting to first base.

SAVE TIME, MONEY AND UNNECESSARY HANDLING

By Straightening Kellys and Drill Pipe The Modern Way



Baker Kelly Straightener in position on rotary table

WHILE THEY ARE SUSPENDED IN THE DERRICK

It's Easily and Economically Done with a BAKER PORTABLE HYDRAULIC KELLY AND PIPE STRAIGHTENER

This highly efficient and easily operated device utilizes the principle of the hydraulic ram, applying the force built up by a manually operated pump to the bend in the Kelly, Drill Collar, or Drill Pipe, as it hangs suspended in the derrick.

COMPLETELY PORTABLE

The entire unit is completely portable (weighing only 1200 pounds), and can easily be transported to the well on a small "pick-up" truck or trailer and set up on the rotary table by means of the catline.

ADVANTAGES OF STRAIGHTENING AT THE WELL

Even though shop facilities may be close at hand, there are a number of important advantages in straightening at the rig—advantages that result in substantial savings in time and money. Probably more Kellys are bent during transportation and in being laid down and picked up than from any other cause. Frequently a Kelly that has just been straightened will again be bent during the process of transporting it back to the well, rolling it off the truck and dragging it into the rig.

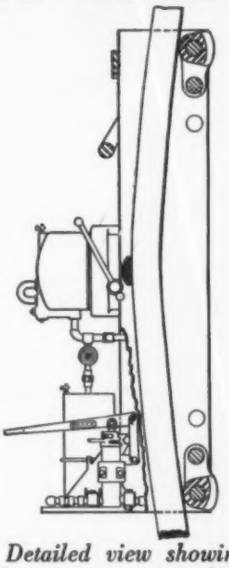
When the BAKER KELLY STRAIGHTENER is used, the job is done right on the rotary table with the Kelly hanging in its normal position. The hazards involved in transportation and handling are entirely eliminated as are also the cost of transporting the Kelly to and from the well, plus the time and expense entailed in removing and replacing it. In foreign or isolated fields, however, the Baker Kelly Straightener is considered indispensable as the cost and loss of time involved in transporting a bent Kelly or drill pipe to and from a distant shop makes it a serious matter.

CAN BE ADAPTED FOR HORIZONTAL PIPE STRAIGHTENING OPERATIONS

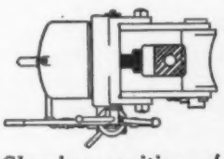
By the attachment of a simple, easily installed device the Baker Kelly Straightener can also be adapted for efficient, horizontal pipe straightening work. The same high efficiency and portability is maintained, plus the advantage of being able to utilize the Straightener for a wide variety of pipe straightening operations around the field and in the shop.

Send today for Complete Details and Prices

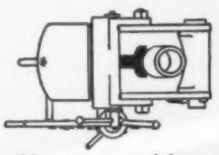
See Pages 270-272 of the 1940 Composite Catalog



Detailed view showing how ram contacts bend in Kelly or Drill Pipe



Showing position of Kelly in Straightener during operation



Showing position of Drill Pipe in Straightener during operation

BAKER OIL TOOLS, INC.

MAIN OFFICE AND FACTORY

6000 So. Boyle Ave., Los Angeles, California, P. O. Box 127, Vernon Station

Central Division Office and Factory
P. O. Box 3048, Houston, Texas

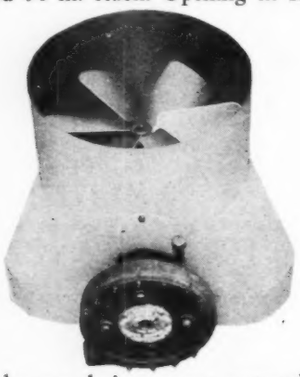
Export Sales Office
19 Rector Street, New York City

BAKER PORTABLE KELLY AND PIPE STRAIGHTNER

MACHINERY and EQUIPMENT

Coffey Robot Stack Draft

THE Coffey Robot Stack Draft, manufactured by the Wilson Supply Company, Houston, Texas, consists of a turbine-driven fan-type blower mounted inside a specially designed 36-in. stack. Opening in front



of the stack is a vent extending through it, and open on the other side. The fan and turbine unit is inserted in this vent, the fan being bolted to its shaft after installation.

Power is transmitted from the turbine to the fan by a ball-bearing-mounted driveshaft, through two bevel gears operating in an oil bath. The turbine is affixed to the end of the gear box far enough from the stack to permit quick and easy connecting of a gas or steam line.

The turbine is driven by gas when natural gas is the fuel used, and by steam when firing with oil. When natural gas is used, the fuel gas supply line is connected directly to the turbine intake manifold. The exhaust manifold is connected to the burners in the boiler fire box. By this hookup the volume of fuel gas required to fire the boiler passes through the turbine, which drives the fan-type blower inside the short stack. The speed of the blower is governed by the volume of fuel gas that passes through the turbine; therefore, the amount of induced draft created is always in proportion to the volume of fuel gas burned.

The Coffey Robot Stack Draft retards natural boiler draft through the use of a short stack. When steam requirements are low and only a small volume of fuel gas is needed to maintain steam pressure in the boiler, the speed of the blower is automatically reduced to idling, so cold air is not pulled through the boiler as it is when using tall stacks. Maintaining an even temperature through the fire box at all times, the Coffey Robot Stack Draft cuts boiler repair bills, it is asserted. Flues and flue sheets are protected by not being subjected to a draft of cold air, which causes sudden contraction of metals at high temperatures each time the fire is quickly reduced.

The Coffey Robot Stack Draft increases fuel economy in three ways, it is stated:

(1) Proper regulation of draft produces more efficient combustion of fuel gas as steam requirements fluctuate, (2) it does not cool the boiler and reduce steam pressure by pulling cold air through the fire box when the fire is low, and (3) it does not waste the large volume of steam (10 percent of total generated) required to operate the conventional steam stack blower.

B and W, Inc., Wall Cleaning Guide

UNIFORM cement distribution around the casing is required to separate gas-, oil-, and water-bearing sands, and in addition the mud cake should be removed from the wall of

(Continued on Page 166)

Universal Mud Gun

A NEW type of mud gun has been developed by Patterson-Ballagh Corporation. This type will supplement the standard Safety Mud Gun that has been marketed by the company for several years, officials state. The new Super Universal Mud Gun is designed with a double flow, but with a single outlet. The double flow eliminates the hydraulic reaction that causes mud guns to spin. Two flow lines form a "Y" fitting from the double flow element, connecting with the outlet pipe. A locking device holds the gun in any desired fixed vertical position and the operating handle is adjustable to different angles to best meet the convenience of the operator.

This gun was designed particularly for services where mud must be jetted on a 24-hour basis. Rubber nozzles are available. The inlet and outlet discharge of the gun is 2 in. The complete assembly weighs 84 lb.

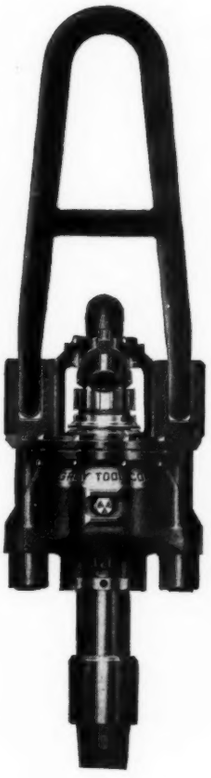
Further details may be obtained from the Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles.

Lunkenheimer Display on Wheels

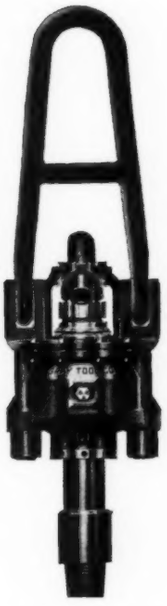
ILLUSTRATED herewith is the Lunkenheimer Display On Wheels, which is touring the Mid-Continent area, bringing to the door of oil company purchasing and operating executives a comprehensive exhibit of valves and specialties used in the oil industry. A Lunkenheimer representative accompanies the exhibit to explain the various products and their application.

GRAY ROTARY SWIVELS GIVE MORE STRENGTH WITH LESS WEIGHT

Gray Type "B" Swivel for heavy duty



Gray Type "F" Swivel for medium heavy duty



Gray Type "J" Swivel for light duty

A record of 12 years of outstanding performance in all parts of the world, under every conceivable condition, is convincing evidence of the reliability, economy and efficiency of Gray Rotary Swivels.

These swivels combine the advantages of more **strength** and **less weight.** This combination is made possible by an original method of suspension, a careful choice of tested materials, extreme accuracy in manufacturing.

Ask a Gray representative to explain in detail the points of excellence which account for the efficiency and long life of Gray Swivels.

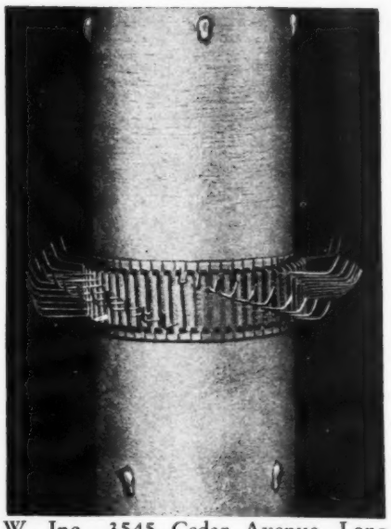
GRAY
TOOL COMPANY

HOUSTON

the hole so that the cement is in bond with the formation.

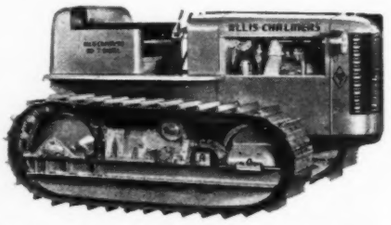
The illustrated Wall Cleaning Guide, manufactured by B and W, Inc., combines a centering action with a means for removing the mud filter cake and is installed on the casing opposite shale sections above and below productive sands so that movement of the casing during the cementing operation will remove the mud cake and enable the cement to be uniformly distributed behind the casing. Where blank casing is to be cemented over productive sands or as a protective string to prevent gas blow-outs the wall cleaning guides provide means for obtaining proper cement distribution around the lower casing joints, the manufacturer asserts. Recent investigations have shown the need for mechanical abrasion of the well bore to obtain mud removal during the cementing and completion operations, it is stated.

For further information write B and W, Inc., 3545 Cedar Avenue, Long Beach, California.



Allis-Chalmers Model "HD 7" Tractor

THE announcement by the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, of its new 54-hp. Model "HD 7" increases its line of 2-cycle General Motors Diesel-powered tractors to three models. The others are the 79-hp. "HD 10" and the 108-hp. "HD 14."

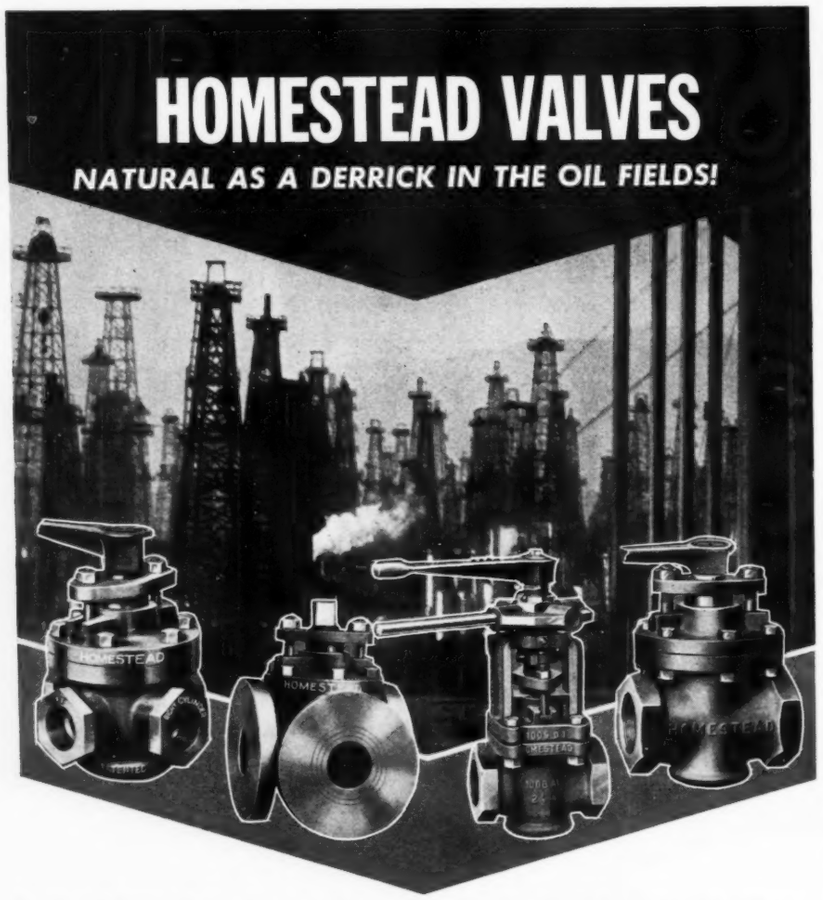


In addition to the low fuel consumption and smoothness of operation of its full Diesel engine, the "HD 7" offers all the other money-saving features of its "big brothers," the manufacturer asserts.

Included in these features, as enumerated by the makers, are the following:

Because of their valuable heat conducting quality, Velvetouch bimetallic clutches and brakes last longer, require less maintenance, and speed-up tractor operation. The positive seal truck wheels and idlers used exclusively on the a-c. tractor line, require lubrication only once each 200 hours of operation. Less lubricant is used during the life of the tractor and servicing time is converted into dirt moving time. Another mportant feature of the "HD 7" is the new track release spring mechanism that reduces wear on tracks and prevents unnecessary strain on other tractor parts.

This new 54-hp. tractor weighs approximately 13,000 lb. in the 63-in.



Twin virtues of *extra long life* and *extremely low up-keep* make Homestead Valves a natural selection for fluid control in the producing and refining industries. Outstanding performance such as that of 30-8″ and 4″ Homestead Valves serving for 12 years on temperatures to 1120° F. and pressures to 200 pounds, or 42-6″ Valves on hot tar for 15 years, is due to "built-in" features, such as protected seating surfaces, positive cam or lever sealing, straight line flow, and quick opening or closing. That's why engineers and operators who build their pipe lines, refineries, and production units for lowest cost per year operation, specify and order Homestead Valves.

HOMESTEAD VALVE MFG. CO. P. O. Box 14 Coraopolis, Pa.

HOMESTEAD VALVES

Send for Reference Book No. 38; and for special prices on your quantity valve requirements.

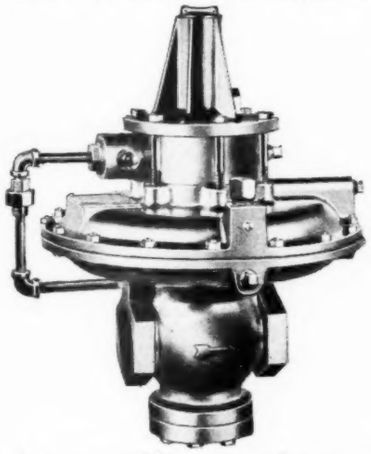
tread model. The 52-in. tread machine weighs approximately 12,500 lb. The four-speed transmission gives a choice of forward speeds from 1.84 to 5.82 m.p.h. Reverse is 2.19 m.p.h.

Standard equipment of the new "HD 7" includes the G.M. 2-cycle Diesel engine, 16-in. track shoes, positive seal truck wheels and front idlers, Velvetouch bimetallic steering clutches and brakes, full width crankcase guard, muffler, adjustable radiator shutters, and electric starting and lighting equipment.

Equipment suitable for use with the "HD 7" includes 5 yard, two- or four-wheel scrapers, eight to ten foot blade graders, sheep's foot rollers, seven-yard wagons, bulldozers, angledozers, and others.

Emco Introduces New Pressure Regulator

THE Pittsburgh Equitable Meter Company, has rounded out its line of control equipment with the Emco "1001" Regulator. It is asserted by the manufacturer, as the name implies, to have a "thousand and one" types of application. It is also stated that through the use of this regulator,



it is now possible to control pressure with a high degree of accuracy for any outlet setting of from 2 oz. to 20 lb., having rates of flow well in excess of the capacities normally transmitted through 2-in. piping.

The manufacturer states that the excellent performance of this regulator is obtained by employing a method of diaphragm loading not previously available on medium and small size regulators. Regulators of conventional design use a spring or weights to oppose the controlling pressure that actuates the operating diaphragm. In the design of the Emco "1001" Regulator a pilot loading system for diaphragm control is incorporated that, it is said, assures the movement of the main operating diaphragm with the slightest change in the control pressure. It is asserted that this principle of control assures the maintenance of the desired pressure at a definite and unvarying amount from minimum flow rates to the maximum capacities that can be obtained under the existing pressure conditions, and that the lock-up characteristics are exceptional.

This regulator is designed to provide accurate control for installations having both small and large flow rates, when supply pressures as great as 150 lb. must be reduced to 20 lb. or less. In this category are large gas appliances, boiler plants, and industrial heat-treating furnaces. The Emco "1001" Regulator is also well suited to small town-border station requirements and may also be employed for district regulator installations when systems are operated at intermediate pressures or at intermediate and low pressures combined.

The Pittsburgh Equitable Meter Company, manufacturers of the Emco "1001" Regulator, has prepared a comprehensive bulletin, making use of four-color sectional diagrams to illustrate the operating principle. This bulletin, No. 1059, can be had by addressing a request to the manufacturer at 400 North Lexington Avenue, Pittsburgh, Pennsylvania.

ALL GUMMED UP?

Otis Scrapers Remove Paraffin Without Stopping Well Flow—Here's How . . .

THE OTIS AUTOMATIC PARAFFIN SCRAPER offers the cheapest and most positive method of **keeping** flowing wells free from paraffin accumulations. **The initial cost is the only cost.** Well flow is used for the entire operation of cutting and removing the paraffin. The scraper remains in the well between operations ready for use at regular intervals. There is no lost production time . . . no paraffin solvents to be continuously bought nor tubing to be pulled and cleaned. An exclusive feature of the Otis Automatic Paraffin Scraper is the combination stop and shock absorber which may be set at any depth without pulling tubing. This scraper is equally effective in wells with high or low rates of flow.

THE OTIS WIRE LINE PARAFFIN SCRAPER may be used to remove paraffin from a number of wells that need cleaning at less frequent intervals than those for which Otis Automatic Paraffin Scrapers are recommended. With this scraper, **many operators are now cleaning 5 or 6 wells daily as compared with 1 or 2 by old-fashioned methods.** The Otis Wire Line Paraffin Scraper is run under pressure on a steel line, on its downward course drilling out paraffin deposits which are removed by well flow. Comes complete with wire line socket, stem and stroke jars and choice of rotating or jar-down type cutters. Both Otis Automatic and Wire Line Paraffin Scrapers are being used extensively in this country and in South America.

Write or call nearest Otis representative today

"Don't Kill Your Well" Call OTIS

OTIS PRESSURE CONTROL, INC.

DALLAS, TEXAS

Division Offices: Houston, Oklahoma City, Hobbs
Export Office: 74 Trinity Place, New York, N. Y., U. S. A.
Representatives: Otis Eastern Service, Inc., Wellsville, N. Y.
Western Pressure Control, Inc., Los Angeles, California

Johnston Mud Weight Indicator

M. O. JOHNSTON Oil Tools, Inc., Los Angeles, California, has announced development of a new electrical instrument that continuously indicates the density of rotary mud while drilling.

The instrument, known as the Johnston Mud Weight Indicator, continuously indicates on an easily-read dial the density of the mud in lb. per cu. ft. Readings on the dial can be made to within ¼ lb. If desired, the unit can be supplied calibrated for wider weight ranges than regularly supplied (62.4 to 90 lb. per cu. ft.). It is also available calibrated in either the metric system or in lb. per gal.

By giving accurate readings of mud weight at all times, this instrument assures greater safety and efficiency in all types of drilling, because it instantly notifies the driller when dangerous weight changes occur, the makers point out.

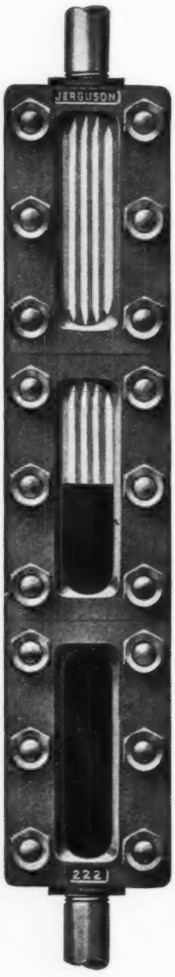
Another important feature is that the instrument can be used with equal efficiency to measure, continuously, the density of cement slurry being mixed for cementing operations. For this purpose the instrument is supplied calibrated to weigh slurries from 80 to 130 lb. per cu. ft.

The Johnston mud weight indicator operates on an unusual electrical principle whereby a small power coil electrically operated induces vibration in a unit consisting of an output coil, a

reed, a reed mount, and a paddle. Immersion of this vibrating paddle in rotary drilling mud causes its vibration to be dampened by virtue of the resistance to its movement caused by inertia of the mud, which is a function of the mud weight. This dampening of the paddle and subsequent dampening of the reed mount attached immediately thereto causes the reed to vibrate at a given amplitude and move the abovementioned output coil attached to its end through a permanent magnetic field. This movement causes voltage to be induced in the coil and current to flow through an indicating meter to which it is electrically connected. Varying degrees of dampening, as afforded by muds of different density, cause a subsequent change in the amplitude of the reed and consequently electrical currents of varying magnitude, depending on the mud weight, are produced. Calibration of the electrical meter to indicate these varying currents in terms of density or lb. per cu. ft. enables the operator to read directly on this scale the weight of the mud in which the paddle is submerged.

For further information concerning the Johnston Mud Weight Indicator write to M. O. Johnston Oil Tools, Inc., 3117 San Fernando Road, Los Angeles, California.

JERGUSON



REFLEX GAGES
ARE
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for showing liquid levers in tanks, towers, stills, etc. Ideal for gasoline, kerosene, oil — no matter what the color of the liquid.

Easy to read because . . .

Empty space shows
WHITE

Liquid level appears
BLACK

Dependable at high and low temperatures and pressures — that means effective protection to men and equipment.

There's a JERGUSON GAGE for your plant.

Jerguson Gages are best by every real test.

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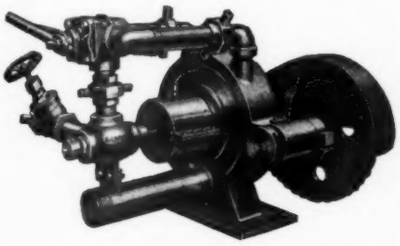
SOMERVILLE MASSACHUSETTS

Gate Closing Engine

SHAFFER Tool Works, Brea, California, is offering a gate closing engine for opening and closing Shaffer cellar control gates or for operating any type of gate valve, master valve, or similar equipment speedily. This engine is designed for steam operation but can be operated on water at slightly less acceleration. It will operate one or two gates.



The power mechanism of the Shaffer gate closing engine consists of a turbine that is reversed by operating a three-way valve, and the speed of which is regulated by a governor valve.

A 2-in. steam line from the boiler connects to a brass gate valve just ahead of the governor valve and thence to the three-way valve. The power device consists of a 16-in. diameter rotor with multiple vanes, enclosed in a steam-tight housing. The perimeter of this housing is made into an annular space that can be compared with the steam chest of a steam engine. This annular space is divided into two circular pressure-tight compartments surrounding the rotor. Through multiple jets, set at the proper angle, the steam impinges upon the vanes of the rotor. One compartment, or steam chest, has the nozzles set to impel the rotor in one direction and the nozzles in the adjacent compartment are set to impel the rotor in the opposite direction. At the three-way valve the steam line is divided into two 2-in. lines, one of which leads to the compartment for forward motion, and the other line leads to the adjacent compartment for reverse motion.

An impact lug near the axis of the driven sprocket engages a similar lug on the countershaft, thus permitting four turns of the rotor shaft and practically one turn of the idler driven sprocket on the countershaft before the lugs contact each other. The speed of the moving rotor at the end of the fourth revolution, or at the time the lug on the sprocket strikes the lug on the countershaft, creates sufficient impact to jar loose a set of tightly closed rams or enables the operator to hammer a gate to the closed position when conditions make closing difficult.

SEALING PRESSURES SINCE 1888

Cut maintenance costs with COOK'S TINIZED* PISTON RINGS

*COOK'S EXCLUSIVE SURFACE TREATMENT

It's the coating of anti-friction metal that . . .

- Reduces Friction
- Promotes Double-quick Seating
- Prevents Cylinder-Scuffing
- Increases Cylinder Life
- Cuts Break-in Costs
- Safeguards Existing Cylinder Glaze When Replacing Rings

. . . Rings that give the ULTIMATE in PERFORMANCE and ECONOMY . . .

FOR doing the basic job of sealing the cylinder, for minimizing cylinder wear, and for long life, COOK'S Rings—made of the tough, carbide-free COOK'S GRAPHITIC IRON—have long since, proved their superiority. Add to these same rings, a coating of non-scuff, anti-friction metal over the entire wearing surface—a coating that ends the delay and danger of damaging cylinders during the break-in process and still further reduces friction and wear—and you have truly the **ultimate** in ring performance and economy.

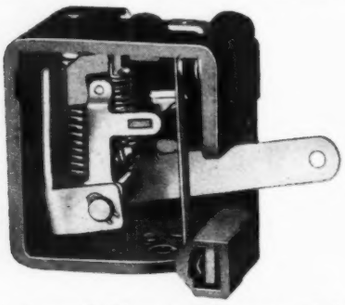
Put in a set of COOK'S TINIZED Rings next time you pull pistons and you'll find that the small extra cost is a "drop in the bucket" compared to the reduction in your maintenance costs. Order COOK'S TINIZED Rings from your equipment manufacturer or direct from us.

C. LEE COOK MANUFACTURING CO.
INCORPORATED
New York Los Angeles Cleveland Baltimore LOUISVILLE, KY. Chicago Tulsa New Orleans San Francisco

TINIZED* COOK'S GRAPHITIC IRON
*NON-SCUFF—QUICK-SEATING—ANTI-FRICTION METAL FACED
Piston Rings

G. E. Sump Pump Float Switch

A NEW float switch designed specifically for domestic sump-pump control has been announced by



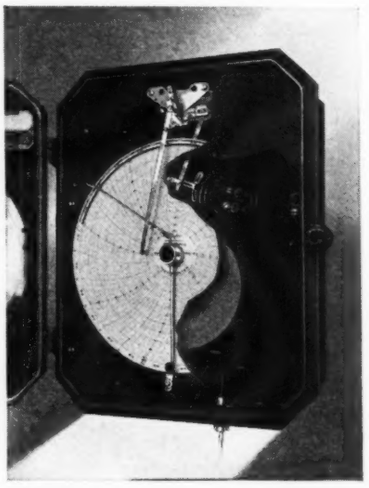
the General Electric Company, Schenectady, New York.

It is a single-pole switch employing an overcenter toggle mechanism. Float-rod weight is counterbalanced by a calibrated spring acting on the operating lever.

Other features include corrosion-resistant parts in the mechanism that permit operation under severe moisture conditions, accessible terminals for easy wiring, a dummy terminal to provide convenient wiring of the "through" side of the line, fine-silver contact tips, and snap-action mechanism. This new control simplifies the design of the sump pump because of the fact that it is actually built for mounting in the motor end-shield or some suitable part of the pump, the manufacturer asserts.

Taylor Recorders

TO PROVIDE truly companion recording instruments for their completely redesigned line of Fulscope controllers, the Taylor Instrument Companies, Rochester, New York, have released their new recorders for temperature, humidity, pressure, load, rate of flow, liquid level, and receivers for pneumatic transmission systems. Ex-



clusive of the controller mechanism, the recorders and recording controllers are identical. Even the cases are drilled and tapped to receive any of the five standard Fulscope control mechanisms should it be desirable to add it at a later date.

The new universal case is for both face and flush mounting. It can be mounted on panels side by side with the previous Taylor recorders because the same dignified lines and pleasing proportions are retained, yet are refined and more efficiently utilized. Standard case finish is instrument-black enamel, or white if specified. Dust and moisture are sealed from the case by neoprene door gaskets and a positive bayonet-action latch.

The time previously required for changing charts is cut in half by a mechanism that combines the chart locking device and pen lifter, the manufacturer asserts.

A die-cast aluminum chart plate gives a rigid surface for pencil notations on chart and for carrying the chart clamp and pen lifter.

Bourdon actuating springs used with temperature and pressure systems possess the same great strength and durability as in former instruments, it is stated. An improved sub-base not only permits more accurate calibration, but also assures precise location of replacement systems in the field for optimum performance, the makers assert.

Streamlined
BRAKE ACTION
The GRIZZLY BRAKE BAND EXCHANGE saves you time, labor and money on all re-line jobs. Ask your supply man, or write direct for detailed information.

Grizzly's *streamlined* brake action is geared to the high speed, deep drilling operations of today — fast, sure braking of the heaviest loads, yet smooth and soft, without jerking or grabbing. Grizzly rotary blocks hold the heaviest loads safely at any depth, speed up drilling operations, eliminate brake and drum troubles, and give maximum ton miles of service.

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GRIZZLY *full-moulded* ROTARY BLOCKS

Pacific Metallo-Seal Pump

THE Pacific Pump Works has introduced a new metal-to-metal seal design pump engineered on the Pacific principle of maximum passages for unrestricted fluid flow. This new Metallo-Seal Pump utilizes the Pacific Maloy Liner Metal for an effective seal as a plunger in a specially finished precision tube, the makers state.

The Metallo-Seal Pump represents the metal-to-metal seal design in its simplest form and gives the operator the advantage of efficient operation at low first cost, according to the manufacturer.

The pump shown herewith is the rod-traveling type with 3-cup hold-down, but any A.P.I. hold-down or locking means may be employed.

The closer fit made possible by the "Molay XX" hard plunger operating in the smooth precision tube greatly reduces fluid slippage and results in a pump efficiency considerably higher than the first low cost would indicate, the makers assert.

Plunger sizes are 1½ in., 2 in., and 2½ in., for tubing sizes of 2 in., 2½ in., and 3 in., in standard lengths.

Elpro Portable Printer

THE NEW Elpro Portable Printer has been designed to reproduce engineering drawings, letters, maps,

charts, printed forms, etc., to a maximum size of 12 in. by 18 in.

Exposure is made by placing the drawing face upward on the Ozalid sensitized paper and locking both in a contact frame hinged to the cabinet proper. The light source consists of six specially designed lamps, and exposure is regulated automatically by a time release switch, and usually takes two to four minutes depending upon the type of original used.

The Ozalid print is developed dry by placing it in a developing chamber situated behind the reflector. Development takes from two to four minutes, and when the print is removed from the developing chamber it is absolutely dry and ready to be used. As many as six prints can be developed simultaneously.

This equipment operates on an ordinary lighting circuit of 110 volts a.c. or d.c. It is light in weight and can be easily moved from place to place and conveniently plugged-in to any electrical outlet. Sold exclusively by the Ozalid Corporation, Johnson City, New York.

THE BIG TOOLPUSHER FOR THE BIG JOB!

"Special:" Capacity 630,000 lbs.

THE MEDIUM TOOLPUSHER FOR THE MEDIUM JOB!

"Clipper:" Capacity 480,000 lbs.

THE LITTLE TOOLPUSHER FOR THE LITTLE JOB!

"Slim Hole:" Cap. 150,000 lbs.

★In all three of these instruments you get the kind of workmanship that makes all Martin-Decker Products famous the world over for accuracy . . . sensitivity . . . and outstanding performance—regardless of operating conditions! Write for complete dope!

HOME OF THE WEIGHT INDICATOR

MARTIN DECKER CORP.

LONG BEACH, CALIFORNIA

SAN JOAQUIN VALLEY: A. F. McQUISTON, BAKERSFIELD, CALIFORNIA
MID CONTINENT DISTRIBUTOR: REED ROLLER BIT COMPANY, HOUSTON, TEXAS

Carbon Dioxide Fire Trucks

CARBON dioxide, the fire-fighting gas originally developed for smothering cargo ship fires, has been given new mobility in recent months with the development of auxiliary fire trucks carrying large quantities of this gas. They are being used in growing numbers by American and foreign refineries and oil fields.

Carbon dioxide gas looks like steam as it is discharged from the pressure cylinders in which it is stored, and it functions by quickly diluting the oxygen content of the air around a fire to the point where combustion cannot take place. The normal oxygen content of the air is 21 percent but by blowing clouds of carbon dioxide on a blaze the oxygen content is reduced to a point below 14 or 15 percent, whereas gasoline requires 17 percent oxygen in order to burn. Furthermore, the gas penetrates past obstructions that interfere with liquid hose streams and is ideal for extinguishing running fires.

(Continued on Page 173)

Designed for a large plant, this truck carries two batteries of carbon dioxide cylinders each manifolded to 200 ft. of hose. Four portable carbon dioxide extinguishers are also part of the equipment for fighting liquid fires.

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Phone: 2060

COTTON VALLEY, LOUISIANA
Phone: 9104

HOUMA, LOUISIANA
Phones: 1252; 160

Acme Pressure Regulators

THE improved Acme Type B-2 and C-2 pressure regulators, manufactured by Acme Regulator Company, Cosden Building, Tulsa, Oklahoma, are designed for inlet pressures to 800 lb. and outlet pressures from 10 to 500 lb.

The regulators are essentially the same in operating principle as that of the heavier all-bronze type made by the manufacturer. The valve and orifice is the conventional oil country ball and seat. A hard, non-corrosive ball and seat that the manufacturer asserts will withstand wire-drawing and cutting action admirably is supplied as standard equipment.

The ball valve is ground to its respective seat to a vacuum-tight closure giving complete shutoff, it is stated.

Types B-2 and C-2 are identical except for the valve and orifice sizes. The Type B-2 has a 2¾-in. California pattern ball and seat and a 1¼-in. orifice diameter. The Type C-2 has a 2¼-in. A.P.I. ball and seat and 1-in. orifice diameter.

Thermoid Improved Line of Rotary Hose

AN IMPROVED line of rotary hose, for all operating pressures and service conditions, has been announced by Thermoid Company, Trenton, New Jersey.

The new Thermoid hose features improved methods in the precision-controlled, machine application of reinforcing wire that Thermoid pioneered five years ago. This method assures absolute uniformity and a minimum of elongation or contraction, the makers assert. The line includes a hose in each of four constructions — for initial test pressures of 7500 lb., 5000 lb., 4000 lb., and 3000 lb.

Another important feature of the improved Thermoid line is a well-known type of built-in coupling.

Extendible Gauge Strips

A NEW TYPE of gauge strip that can be added to, foot by foot, to fit any height, for gasoline, oil, and water tanks, has been developed by J. A. Campbell Company, Long Beach, California. The strips are in units of 1 ft. each, locked together by foot numeral inserts. The numerals are clearly visible at a distance. These strips are cast under pressure from a zinc base alloy in chrome-molybdenum-steel dies. Each strip is 2 in. by 12 in., ⅛ in. thick, and is resistant to all weather conditions, it is stated. Numerals and graduations are raised. Two finishes are available — molybdenum and chromium. The strips can be mounted on a wooden board or metal, fastened to the tank, alongside the gauge glasses. Further details may be obtained from the manufacturer, 645 East Wardlow Road, Long Beach.

Carbon Dioxide Fire Trucks

(Continued From Page 172)

tank car fires, or blazes in pump rooms and other obstructed areas, it is stated.

Some of the newest of the carbon dioxide fire trucks are those recently sold to a South American government by Walter Kidde and Company, New York, New York, for the protection of oil storage tanks at a military airport. They carry more than 1000 lb. of carbon dioxide — enough for enveloping large airplanes or tanks in a cloud of the fire-killing gas. The truck also carries portable carbon dioxide extinguishers that can be lifted off and carried to smother small blazes, and its equipment includes ladders, derrick, grappling hooks, asbestos suits, etc.

The carbon dioxide cylinders are usually mounted on a standard commercial chassis and the trucks can speed to all parts of a field to protect buildings and gasoline stores against fire.

Minimum Wear on Line and Sheave

with . . .

McKissick *Safety* Floor Blocks

This is made possible through use of the Universal Adapter—so designed that plenty of side sway is permitted, without any undue wear on the line or sheave. Ball-bearing swivel assembly permits block to freely swivel under heaviest loads.

Our Safety Floor Blocks are available with base plate or latch-type becket. The guards are so constructed that they do not need to be detached for threading the line, which assures permanent safety during the life of the block.

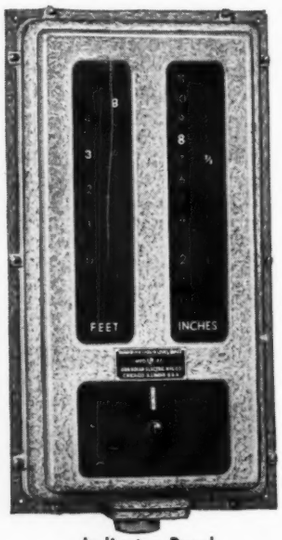
Available in four sizes with single bearing, and two additional sizes with double bearings—sheave diameters from 12" to 24".

At Supply Stores

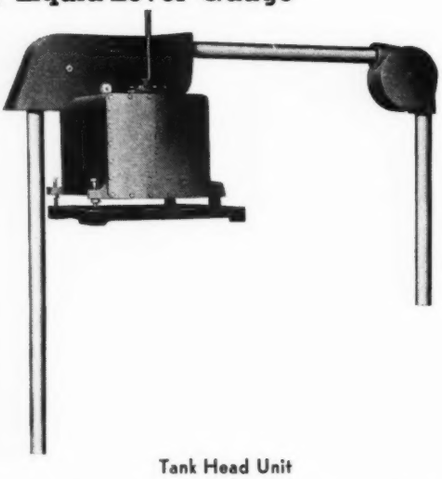
McKISSICK PRODUCTS CORPORATION

TULSA, OKLAHOMA

Remote-Reading Liquid-Level Gauge



Indicator Panel



Tank Head Unit

A NEW remote-reading liquid-level gauge recently announced by Guardian Electric Manufacturing Company is described by the makers as being able to measure liquid levels in tanks of every type now in use, to the nearest ⅛ in. (finer if desired). It is said to be unaffected by temperature, weather, varying specific gravities, or distance between tanks and control office. The manufacturer asserts failure of current supply does not affect accuracy of reading, because power is used only at the time tanks are being gauged.

The unit consists of a fully-protected mechanism sealed in oil, housed in a heavy cast-aluminum tank head having the best of fittings. Bronze gears give long life. Breakdown tests to equivalent of 40 years average use have already been run, with no mechanical wear apparent, it is stated. Float and bridle assembly offers minimum resistance to tank currents, and is designed to pass easily through standard manholes. The float displaces 1/16 in. of liquid and operates the control mechanism on as little as a 4-oz. pull. Gland sealing of tape exit through tank top, plus closely-fitting aluminum pipe leading to tank head housing, permit use of gauge on all types of sealed tanks without danger of vapor loss due to pressure or loose fittings, the makers state.

The indicator panel can be connected to any number of tanks to 24 standard, or more if desired. Each tank is gauged by a turn of the dial to the number of the tank to be gauged, whereupon, by simply pushing a button, the exact depth lights up on the indicator panel. Feet appear in red numerals, inches and fractions in green. The new Guardian remote-reading liquid-level gauge may be used on tanks to 50 ft. in height.

More complete details may be obtained by writing direct to the manufacturer, Guardian Electric Manufacturing Company, 1621 West Walnut Street, Chicago, Illinois, for Bulletin G40.

TALK ABOUT PRECISION

—you get it with a "TOLEDO" Geared Pipe Cutter.

You can cut off an eighth of an inch from the end of a piece of pipe if desired. You get clean, square end cuts without burr.

"TOLEDO" Geared Cutters can be split apart and clamped around pipe already in line and the pipe cut off without trouble. "TOLEDOS" are recognized as the most accurate pipe cutters made.

They are furnished with regular high-speed, double-ended cutter blades or can be furnished with special knives and adaptors for bevelling pipe if desired.

Four sizes: 2½" to 6"; 4½" to 8"; 7" to 10"; 9" to 12". Write for full details or order from your local distributor.

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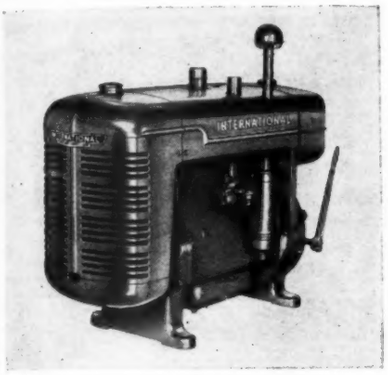
YOU WILL DO BETTER WITH A "TOLEDO"

International 22-hp. Power Unit

THE new, modernly styled International U-2 power unit shown in the accompanying illustration is a compact, 4-cylinder, valve-in-head engine, with 3-in. bore and 4-in. stroke. It develops 22 net hp. when operating on



gasoline at regular full-load governed speed of 1800 r.p.m. Equipment for operation on natural gas, distillate, or kerosine is also available.

A combination chamber is shaped to give complete control of rate of combustion and prevent engine "knocking." Low fuel consumption with maximum power output and increased engine life result from this combustion control, the manufacturer, International Harvester Company, Chicago, Illinois, states.

An oil filter with an inexpensive, efficient, replaceable element keeps the oil clean and makes it possible to use the oil a long time without change, it is asserted. A gear-type pump delivers oil under pressure to the engine parts through drilled passages. Main and connecting-rod bearings are of the easily replaceable precision type. The crankshaft is electrically hardened by the Tocco method—a high-frequency induction process that makes the bearing surfaces file hard but leaves the rest of the shaft tough and strong to withstand stresses. Cylinders are easily replaceable with exact duplicates, which make longer engine life possible.

The governor is of the lever-adjusted, variable-speed, fly-ball type and has full control of the throttle at any engine speed from 1000 to 1800 r.p.m. Governor springs giving close regulation at 1200 r.p.m., as required for generator service, are available.

Bore and stroke are 3 in. and 4 in., respectively, and piston displacement is 113.1 cu. in. Maximum net torque is 78 lb-ft. at 1000 r.p.m. The single-plate clutch is 9 in. in diameter and is of the over-center type. A spring-loaded clutch is also available. Approximate weight of the new U-2 (less fuel, oil, and water) is 665 lb. Overall length is $50\frac{11}{16}$ in.; width, $20\frac{5}{8}$ in., and height, $40\frac{1}{4}$ in.

Welding Tee Announced

A NEW LINE of seamless steel welding tees having several distinctive features has been developed by Tube-Turns, Inc., Louisville, Kentucky.

The outstanding feature of this new tee is that full pipe strength is attained through the proper placing of metal at points of higher stress rather than by excess thickness throughout and consequent useless weight, the manufacturer asserts.

It has long been known that stresses due to internal pressure are highly concentrated at the intersection of the

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Top-quality steel wire, topnotch workmanship, well-balanced properties for rotary drilling — that's Yellow Strand. Add preforming, and it's "tops" in *limberness*, too — easy to string, to spool, to splice; highly resistant to kinking, whipping, fatigue, and drum crushing.
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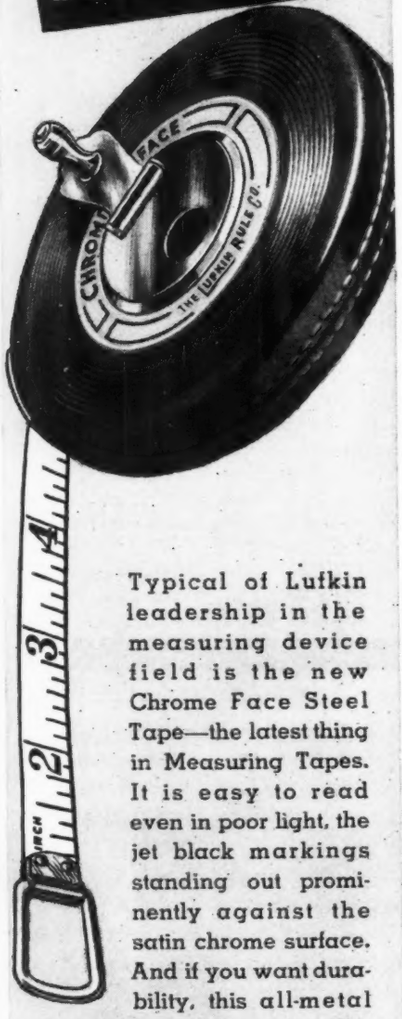
LUFKIN
CHROME FACE STEEL TAPES



Typical of Lufkin leadership in the measuring device field is the new Chrome Face Steel Tape—the latest thing in Measuring Tapes. It is easy to read even in poor light, the jet black markings standing out prominently against the satin chrome surface. And if you want durability, this all-metal tape will surprise you. The smooth, chrome surface won't rust, crack, chip or peel, and is easy to keep clean. Oil men will find it perfectly suited to their needs. See it at your dealers. Write for complete catalog of measuring devices.

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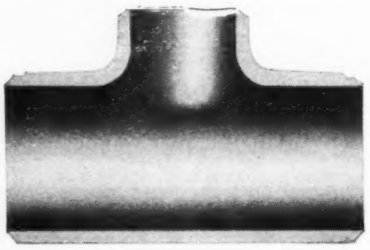
outlet with the run of a tee. Although not a great deal is known as to the



extent and exact location of the maximum stresses existing in the tee, it is generally believed that the greatest stress occurs at the crotch and that it may be, when unreinforced, as much as twice that in straight pipe of the same size under the same pressure.

The new Tube-Turn tee design meets this condition adequately by providing substantially more metal thickness at the crotch, it is stated. The thickness from this point, that is, along the top centerline of the run of the tee, is gradually reduced to nominal at the bottom of the tee where stresses again reach normal when reinforcement at more highly stressed points is ample.

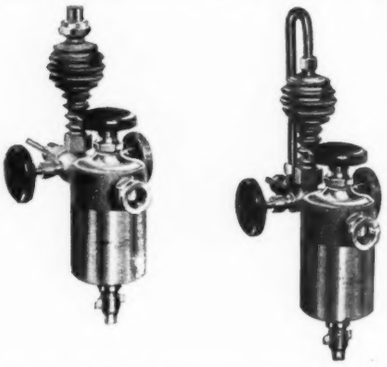
Another important improvement is that longer outlets are provided for greater ease in lining-up and welding. The new Tube-Turn tees are accurately machined, scale-free, and stress relieved, it is asserted.

A new 64-page catalog and data book describing this tee and giving complete information on practically all type of welding fittings and forged-steel flanges is available upon request and may be had by addressing the manufacturers, Tube-Turns, Inc., at 248 East Broadway, Louisville, Kentucky.

"Swift" Sight-Feed Lubricators

AN improved model of the "Swift" Lubricator for steam cylinder lubrication has been announced by the "Swift" Lubricator Company, Elmira, New York. This device is intended for lubricating steam-driven pumps, engines, hoists, hammers, flue cleaners, or internal oiling wherever steam is used. This device is now available in both the single- and double-connection styles, in the 1/4, 1/3, 1/2, 1 pint, and 1 quart sizes.

Knurled composition handles have replaced the wooden valve wheels. This ends any possibility of handles drying-up from the heat of the steam and cracking-off. The knurl enables perfect grip and operation even with oily hands. A new fin-type condensing chamber gives greater condensation capacity and more rapid feed, if necessary, the makers assert. The ribs are so constructed as to greatly increase the resistance of the chamber, thus minimizing the possibility of its bursting as a result of freezing during cold weather. Pyrex glasses are available for pressures to 150 lb. working pressure

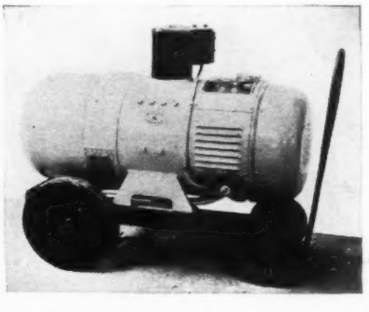


and special high-pressure pyrex glasses and neoprene gaskets are available for pressures to 350 lb. Regulating valves are now packed with a special Garlock solid-ring packing made especially for this lubricator. All castings are made from a nickel-bronze composition to withstand high working pressure.

All improved parts are made to interchange with the 800,000 "Swift" Lubricators now in service.

Remote Control Device for Wilson "Hornet"

A NEW DEVICE for remote control of Wilson "Hornet" arc welders, has been announced by Wilson Welder and Metals Company, Inc., New York, New York. The single control of the "Hornet" is well adapted to operation by this method, the manufacturer asserts. To utilize the new device, the handwheel that governs the control pole of the standard welder is replaced by the reversible motor-driven Type SC remote control device.



Said to cover the entire range of the

machine to which it is attached, in both high and low settings, the new device allows minute adjustments in current output by merely touching to the ground one of two contacts on the electrode holder. In other words, when the electrode holder button marked "more" is brought into contact with the ground, the electric motor in the remote control housing on top of the machine revolves and raises the control pole core, increasing the output. The motor revolves only while actual contact is maintained. When the button marked "less" is grounded, the remote control motor revolves in the opposite direction and lowers the control pole core, decreasing the output. The contact buttons are shaped differently, so that the operator can easily locate the correct one even in poor light.

The 1/80-hp. electric motor, all that is necessary to operate the control pole, is protected by two limit switches and by a slip clutch to prevent damage when the end of the range is reached. The generator may be preset by push buttons mounted on the control itself.

Bowen Junk Basket

A NEW type junk basket for quickly and easily recovering small steel objects lost in the hole has recently been introduced by S. R. Bowen Company, Santa Fe Springs, California. The tool incorporates an unusual principle of fluid circulation that provides inward fluid flow for washing the fish into, rather than away from, the center of the basket body, the manufacturer states. Another feature is that it permits full pump pressure to be applied.

The Bowen Junk Basket consists essentially of a top sub, a combination inner and outer barrel having fluid ports, a ball valve, a junk catcher, and a standard mill-type shoe. As the basket is run in the hole full circulation is maintained through the center of the tool as well as side passages, thus keeping the barrel clean and free from heavy mud. Then by simply dropping a steel ball down the pipe, the entire fluid flow is diverted through the side passages of the barrel. This forces fluid to flow outwardly and downwardly against the circumference of the hole, where it is deflected from the sides in such a manner that all loose objects are washed to the center. The fluid stream, flowing to the center of the tool and upward through it to return ports, creates a reverse-circulating action so that, by opening the pumps to full capacity and rotating the tool on bottom, all material is forced into the center of the barrel where it is trapped and held by the core catcher. The mill quickly cuts a short core in the formation, further aiding in guiding the junk into the basket.

The Bowen Junk Basket can be obtained in a wide range of sizes for all holes to 17 in. in diameter. Various assemblies are available for use on the bottom of the tool.

For full particulars, write direct to S. R. Bowen Company, Santa Fe Springs, California.

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RECTORSEAL is not a petroleum base product, and is insoluble in all petroleum products. It is not affected by salt water or dilute acids, or by steam up to 400°F. It comes to the user in a liquid form and is easily applied with a brush or swab. It forms a plastic, elastic mass which seals quickly and holds the seal indefinitely . . . yet permits easy breakout because it will not "freeze" nor gall, thanks to a natural lubricating quality. Now used world-wide as a leak preventer on threaded and gasket connections. But it from your Supply Store. Free sample sent upon request to Rector Well Equipment Co., Fort Worth, Texas.

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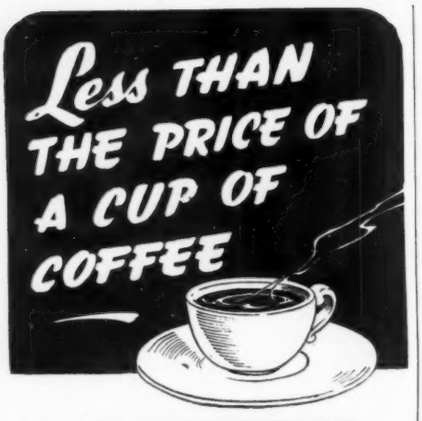


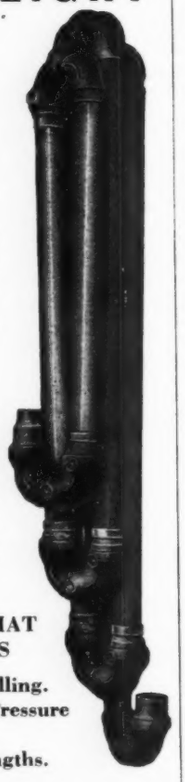
ON THE RECORD

HOSE D-4" 29 Months in Service ★ 70,000 ft. of Hole Drilled	TOTAL HOSE COST* 1½c Per Foot of Hole Drilled.

*Includes purchase price and upkeep.

LIGHT WEIGHT

Chiksan *all steel* Rotary Hose is the lightest High Pressure Rotary Hose built, size for size. Check hose weights for your own satisfaction. All-steel construction assures unequalled strength.



In foreign fields, Chiksan is the ideal hose because of its compactness which assures easy transportation. Further, it is unaffected by climatic conditions.

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4" and 5" for Drilling.
3" for Standby and Pressure Service.
45', 50', 55', 60' Lengths.

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CIRCULATING HEADS • MUD GUNS
THREE-WAY DISC BIT
STANDARD AND HEAVY DUTY REAMERS

To Distribute Pacific Pumps

According to an announcement by George E. Bigelow, president and general manager of Pacific Pump Works of Los Angeles, California, the Mid-Continent Pump Supply Company, Tulsa, Oklahoma, has taken over the distribution, sales, and service in the Mid-Continent area of Pacific Centrifugal Pumps for municipal, industrial, refinery, pipe line, and hot oil service, and Pacific Deep Well Centrifugal Turbines for water wells.

Operations in the area will be under the direction of Roy A. Dunbar, president of Mid-Continent Pump Supply Company, which company has for several years distributed Pacific Deep Oil Pumps in Mid-Continent fields.

Barrett and Turnbull Promoted by Pomona Pump

With the establishment of an executive eastern office at 120 Broadway, New York City, the Pomona Pump Company announces the election of C. L. Barrett, formerly general sales manager, to the office of vice-president in charge of sales, and the appointment of W. D. Turnbull as general sales manager in charge of the New York office.

Turnbull, prior to joining the Pomona organization, was for 17 years associated with the Westinghouse Electric and Manufacturing Company.

Associated with Turnbull in the New York office will be Svend A. Canariis, nationally known water works engineer; G. H. Lambert, eastern district manager; Dan M. Wallace, national accounts, and George H. Shetlin, export sales.

W. L. Martwick Made Vice-President Foster Wheeler Corporation

Foster Wheeler Corporation, New York City, announces the election of W. L. Martwick to the position of vice-president in charge of sales. Martwick has been connected with the corporation since its inception and has had extensive experience in the power plant field.

Martwick graduated from Haverford College with a degree in mechanical engineering and was for sometime president of the Aero Pulverizer Company. When Power Specialty Company absorbed the Aero Pulverizer Company in 1926, he joined the Power Specialty organization as manager of the Pulverized Fuel Division. The Foster Wheeler Corporation was formed in 1927—a consolidation of Power Specialty Company and Wheeler Condenser and Engineering Company—and Martwick progressed through various administrative sales positions of the petroleum refining and power plant departments to that of general sales manager.

Prominent Coating Expert Dies

Jere K. Ross of the Wailes Dove-Hermiston Corporation died on May 15 at Bonnie Burn Sanitorium, Scotch Plains, New Jersey. Ross was graduated as a chemist from Lafayette College, class of 1922, obtaining his master's degree in 1923. He joined the Wailes Dove-Hermiston Corporation as a chemist in the production laboratory in 1928, later becoming field chemist, then superintendent of field operations and shortly before his fatal illness was advanced to manager of the contract department. Ross is survived by his widow and their three children.

R. B. Boand Joins Union Wire Rope Staff

Union Wire Rope Corporation, Kansas City, Missouri, has announced the appointment of Robert B. Boand as district salesman in Texas, with headquarters at Houston. Boand is a graduate of Missouri University. He has been in office sales since 1937 and is a factory trained man.

Personnel Changes Made by Chicago Bridge and Iron Company

The following changes have been made in the personnel of the sales department of the Chicago Bridge and Iron Company, Chicago, Illinois:

S. C. Hamilton, district sales manager at Birmingham, Alabama, transferred to Houston, Texas.

R. A. Williams, who has been handling the sale of Morse filter plants, transferred to the Dallas, Texas, office.

H. F. Stearns, transferred from New York as district sales manager in charge of the Birmingham territory.

A. H. Heineman, transferred from New York to the Birmingham sales department.

Herbert A. Guerin, transferred from Cleveland office to the New York office.

George Jewett, transferred from Chicago to the New York office. Jewett has been at Birmingham.

Ray Menefee has been transferred from the Chicago engineering department to the Cleveland office.

William Fickett has been transferred from the Chicago drafting room to the Chicago sales office.

Kenneth Sandbach is being transferred from the Hillside erection office to the Philadelphia sales office.